Evaluation of peripheral compression and auditory nerve fiber intensity coding using Auditory Steady-State Responses (ASSR)

Encina Llamas, Gerard; Epp, Bastian; M. Harte, James; Dau, Torsten

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27th of August, 2015

International Symposium on Auditory and Audiological Research (ISAAR) , Nyborg (Denmark)

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The need for SUPRA-threshold evaluation

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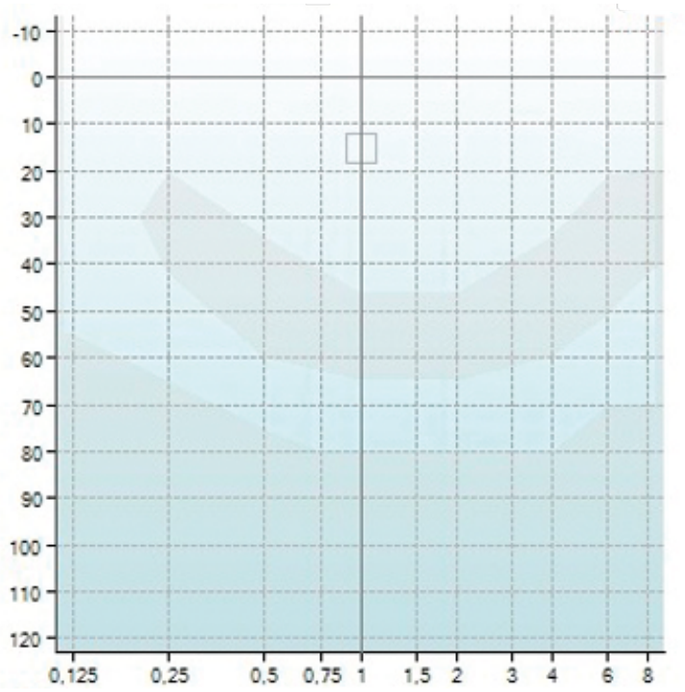

5-10% of patients self-report hearing difficulties while showing normal audiograms

Saunders and Haggard (1989, 1992); Kumar *et al.* (2007); Hind *et al.* (2011)

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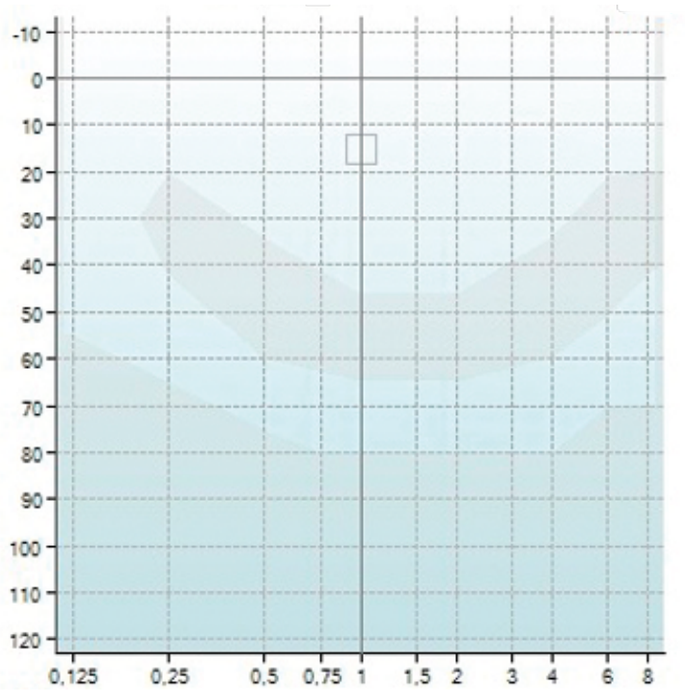

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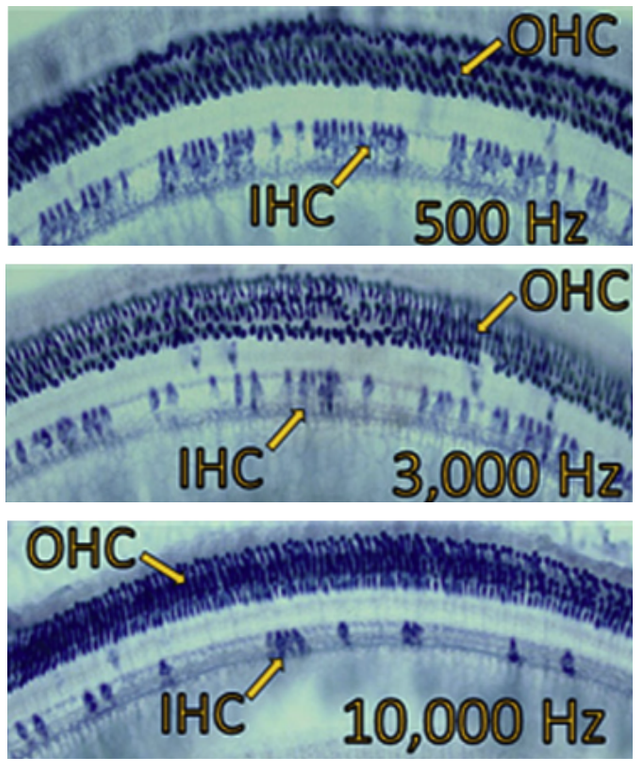

Normal behavioral thresholds with **80% loss** of **IHCs**

Lobarinas *et al.* (2013)

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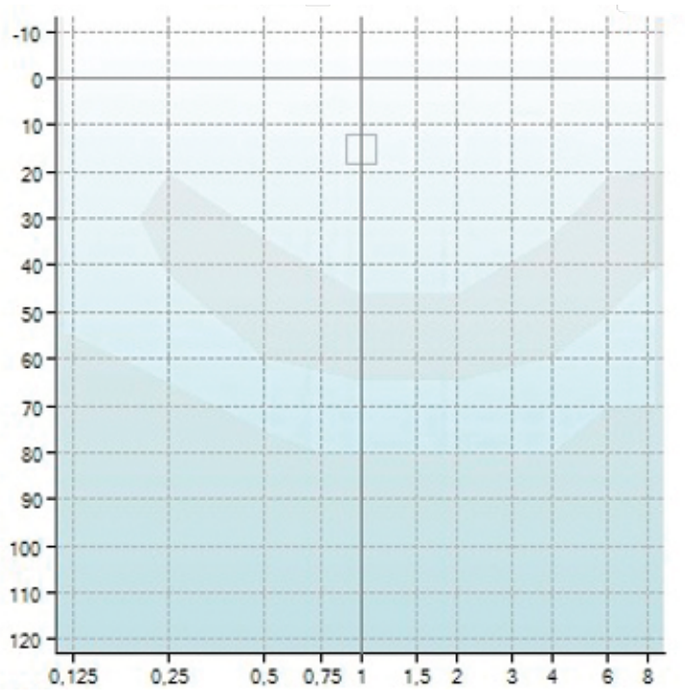

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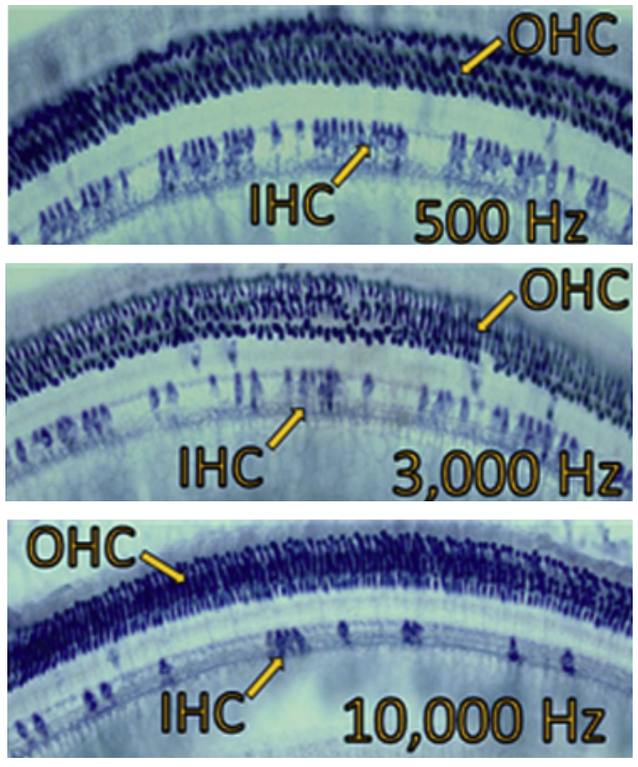

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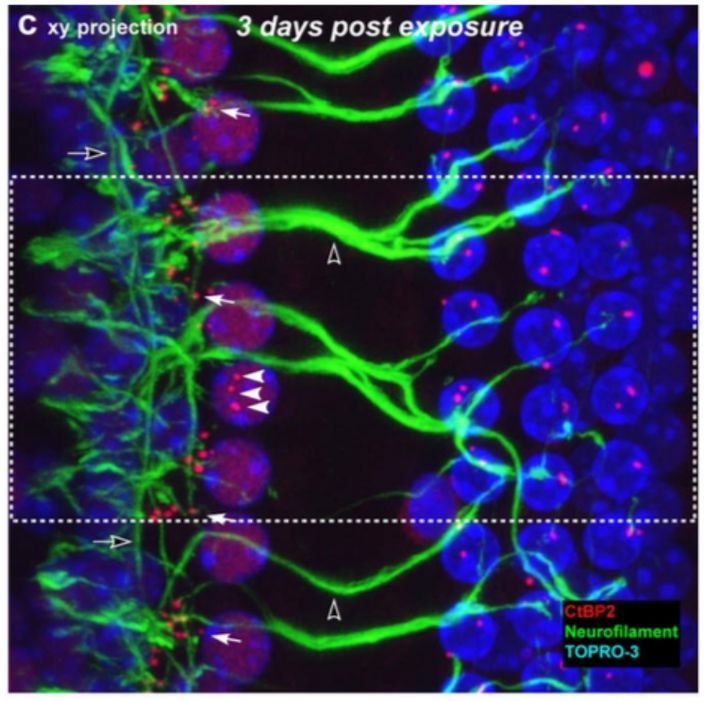

Auditory nerve fibers (ANF) **deafferentation** is **not reflected** as permanent threshold elevation

Kujawa and Liberman (2009), Lin *et al.* (2011), Furman *et al.* (2013)

Compression: Animal data

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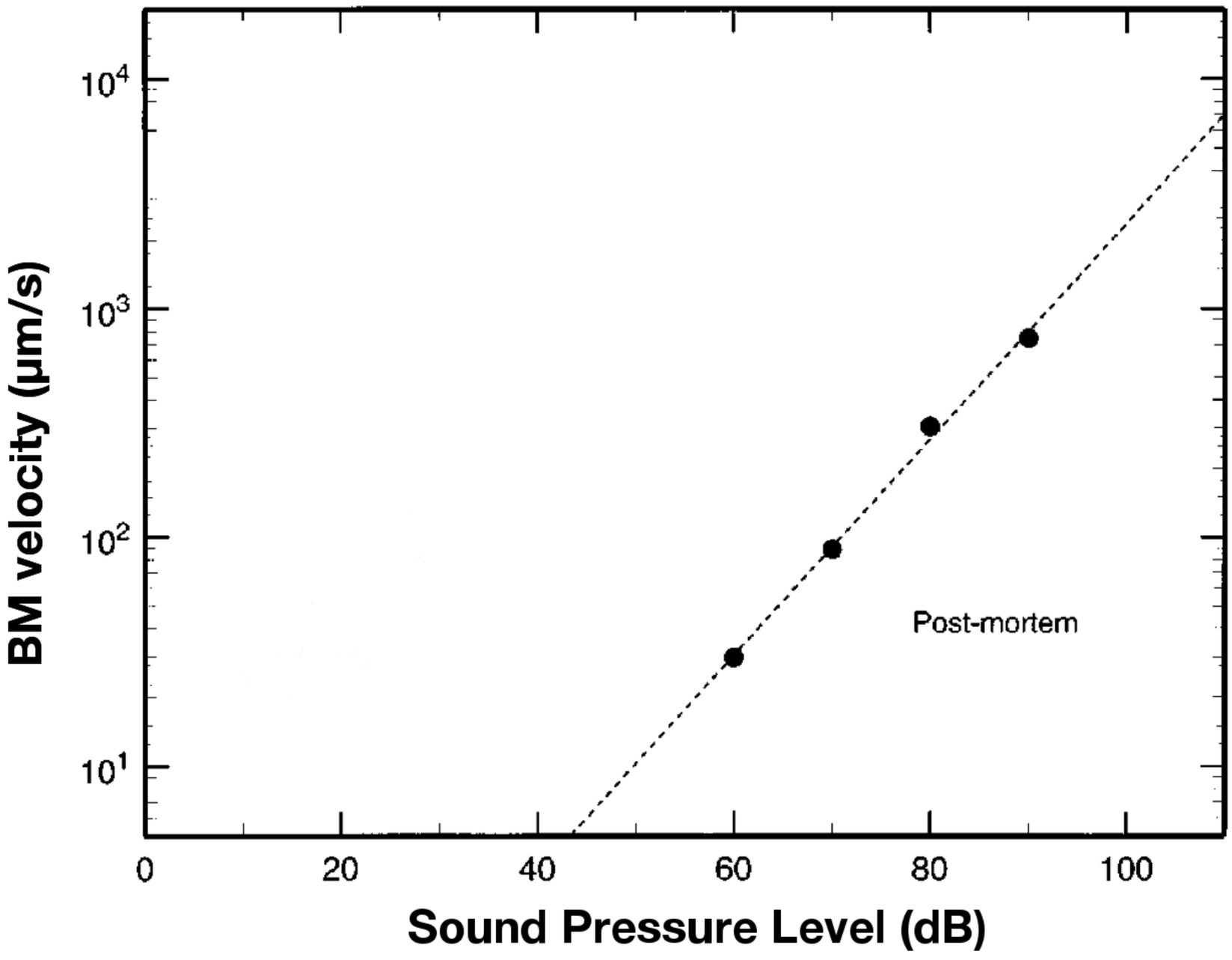
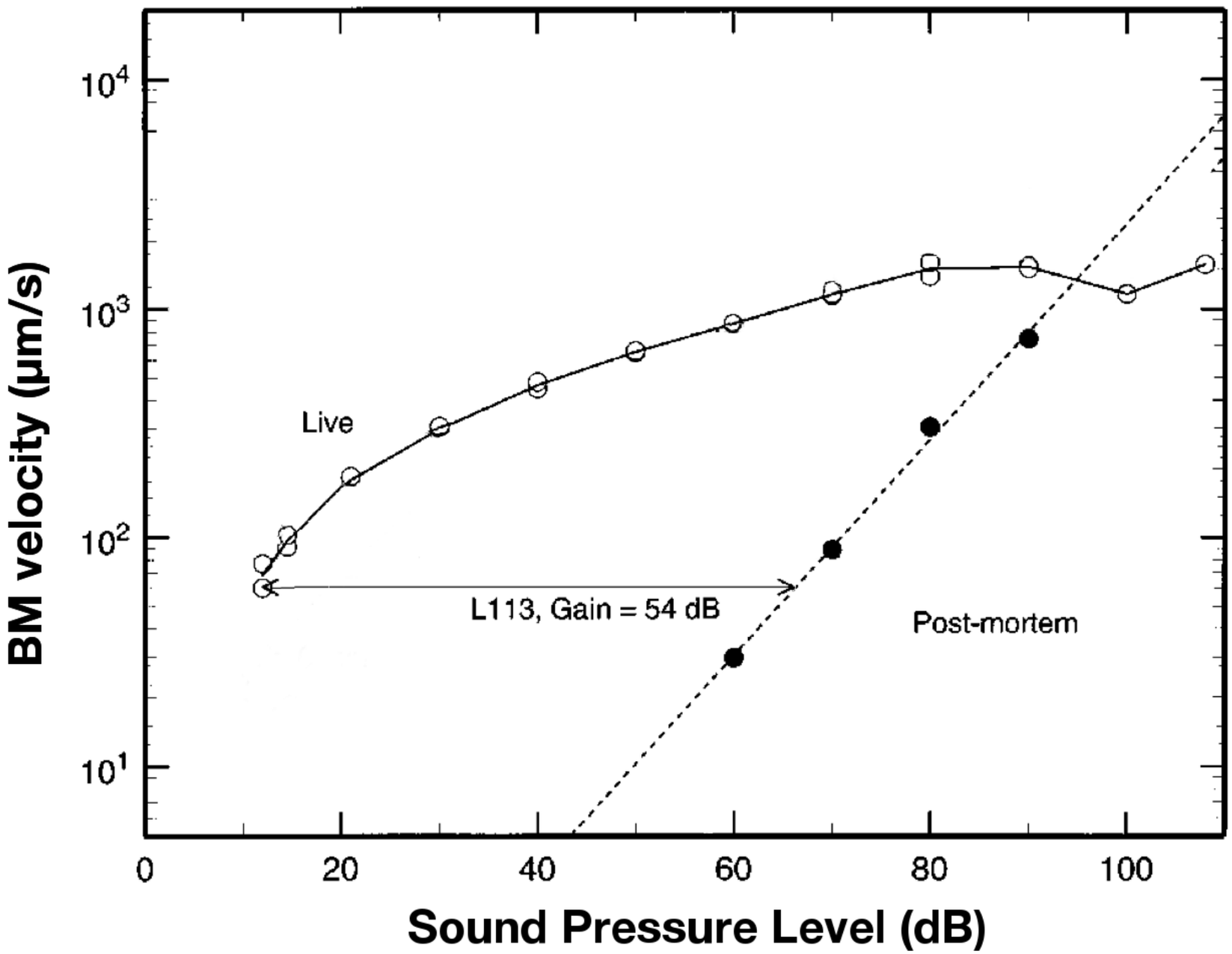


Ruggero *et al.* (1997)

Compression: Animal data



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Compression: Auditory Steady-State Responses

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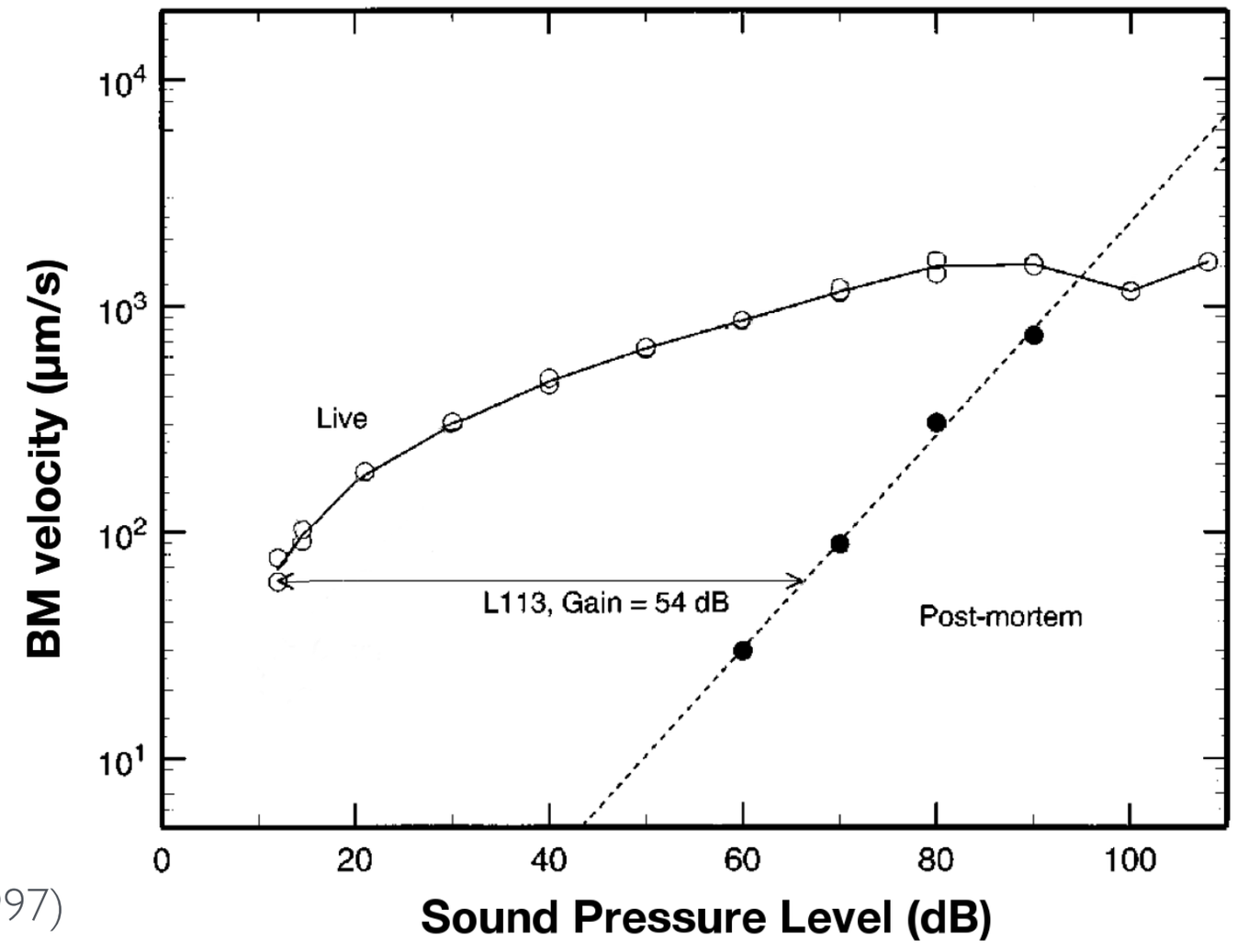
- The **healthy cochlea** shows a **compressive growth** as a function of stimulation level.



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Compression: Auditory Steady-State Responses

- The **healthy cochlea** shows a **compressive growth** as a function of stimulation level.
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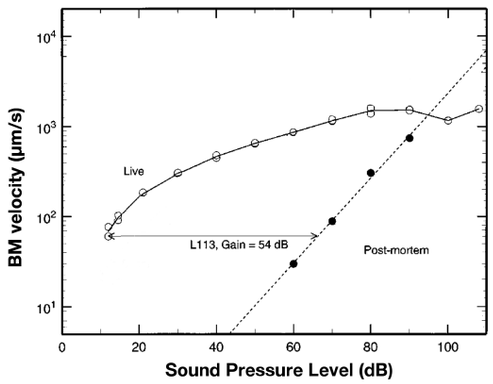

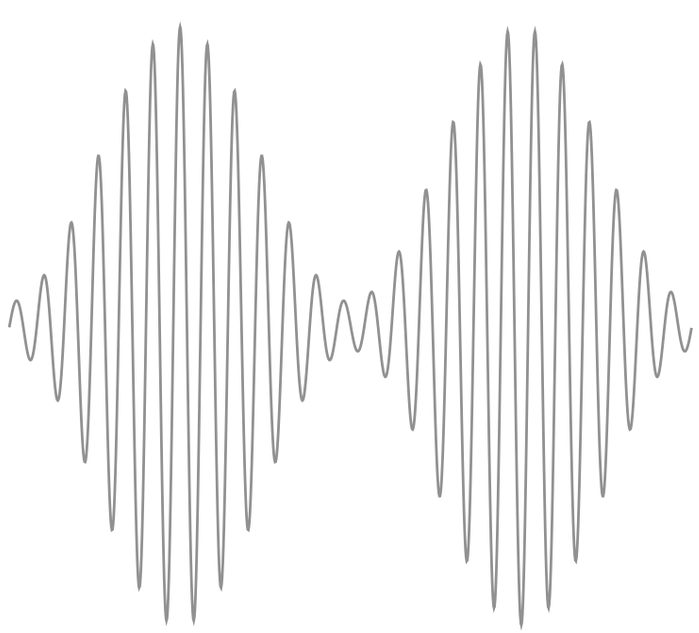

$$A \cdot \sin(2\pi f_c t) \cdot \left[\frac{1 + m \cdot \sin(2\pi f_m t)}{2}\right]$$

1 kHz @ 80 Hz
m = 85%

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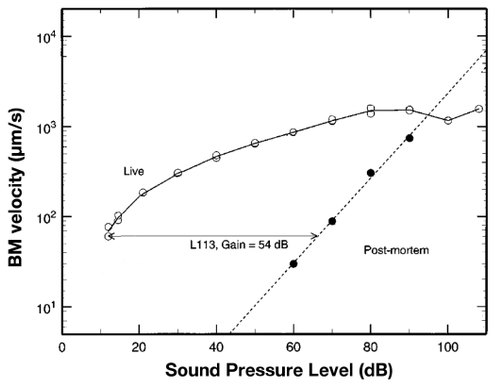

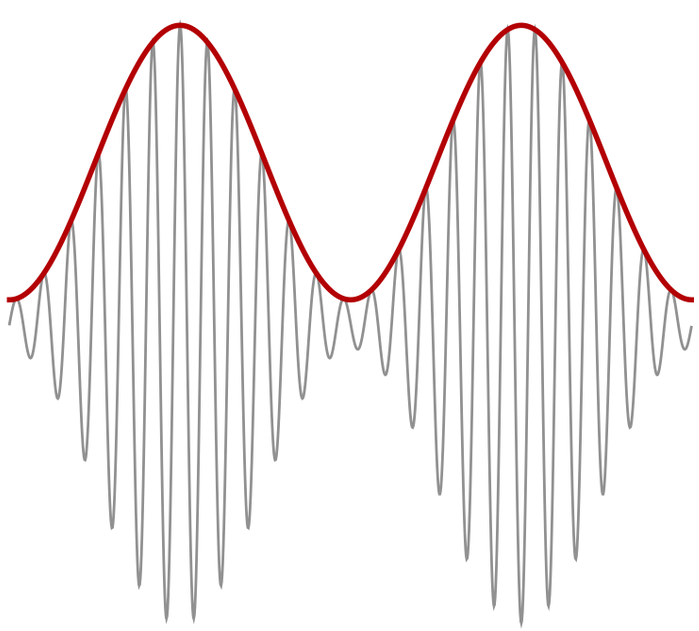

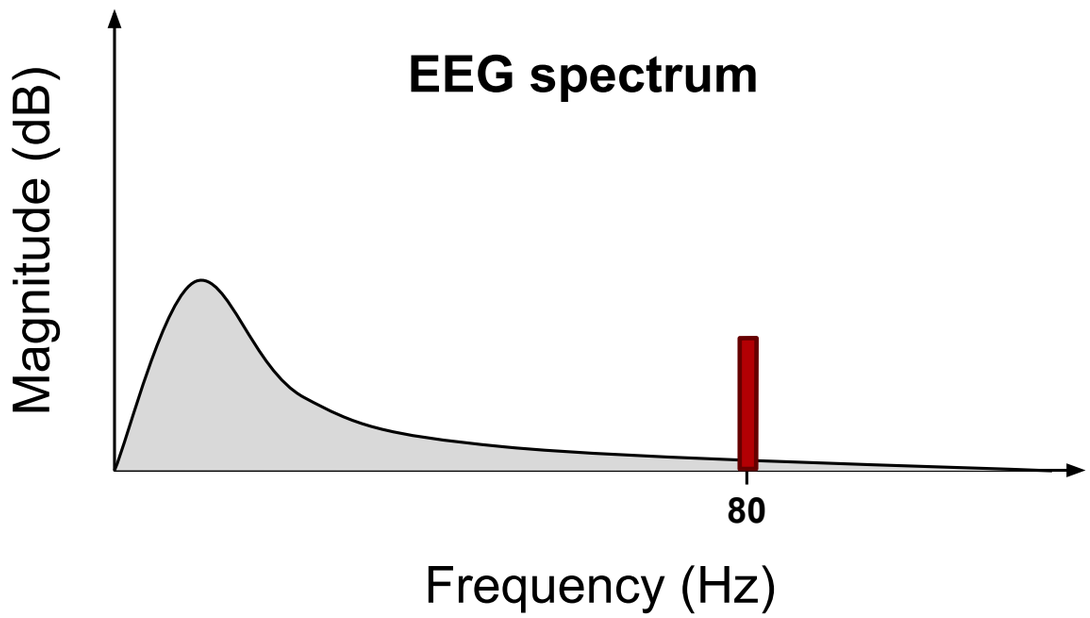

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Compression: Auditory Steady-State Responses

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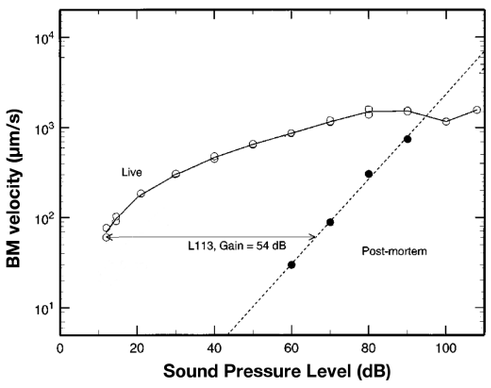
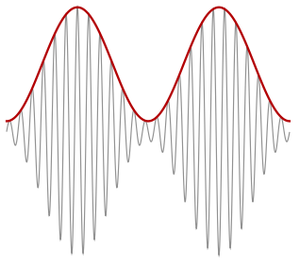
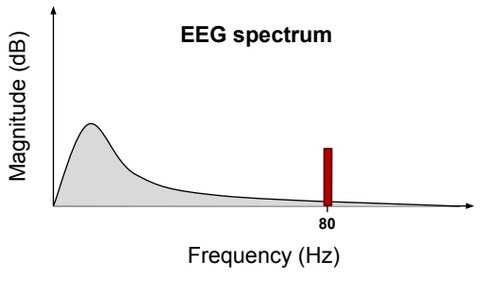
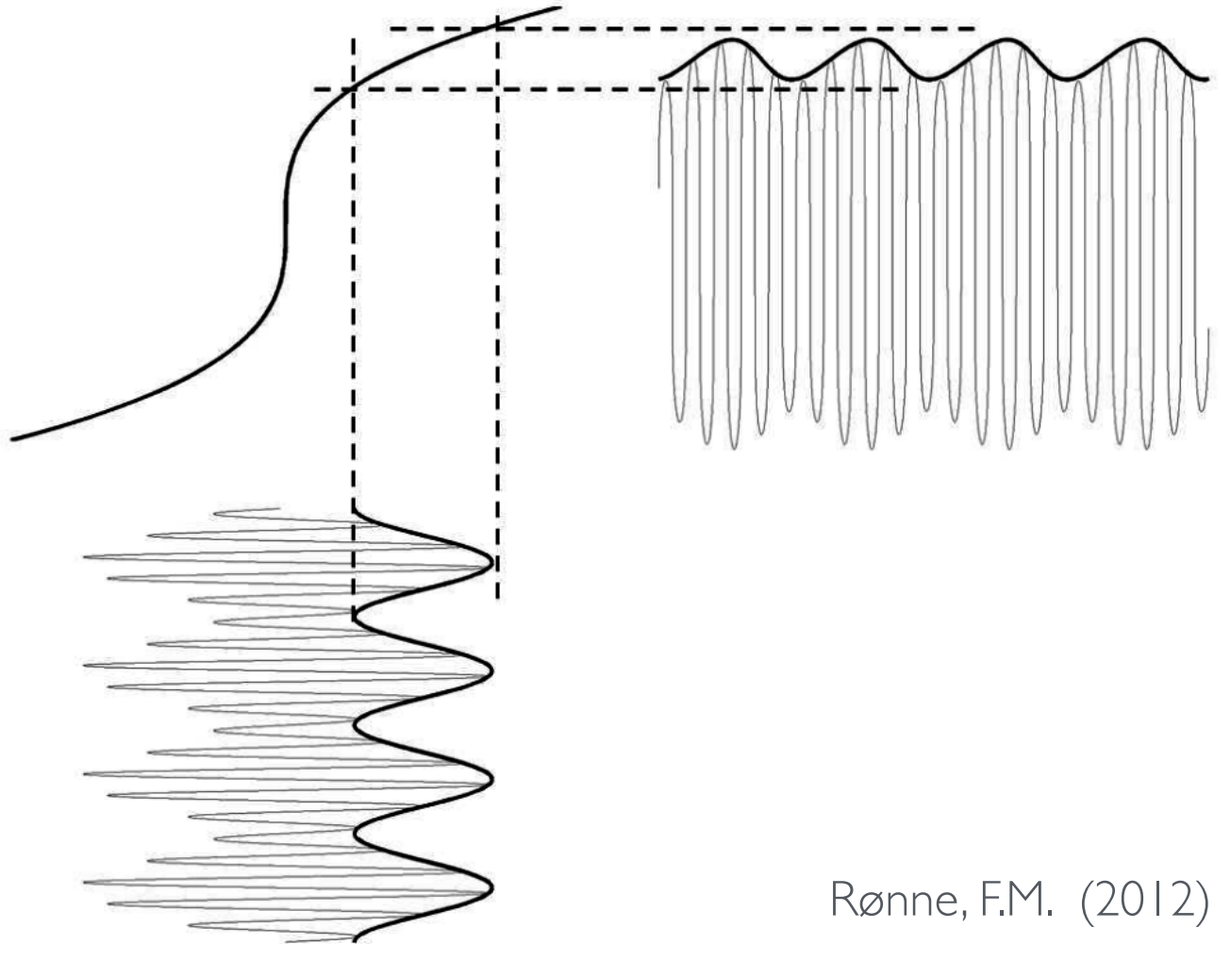
- ASSR reflect **envelope** coding.
- Compression **affects** to the **envelope**, hence it should affect to **ASSR**.









Rønne, F.M. (2012)

Research question

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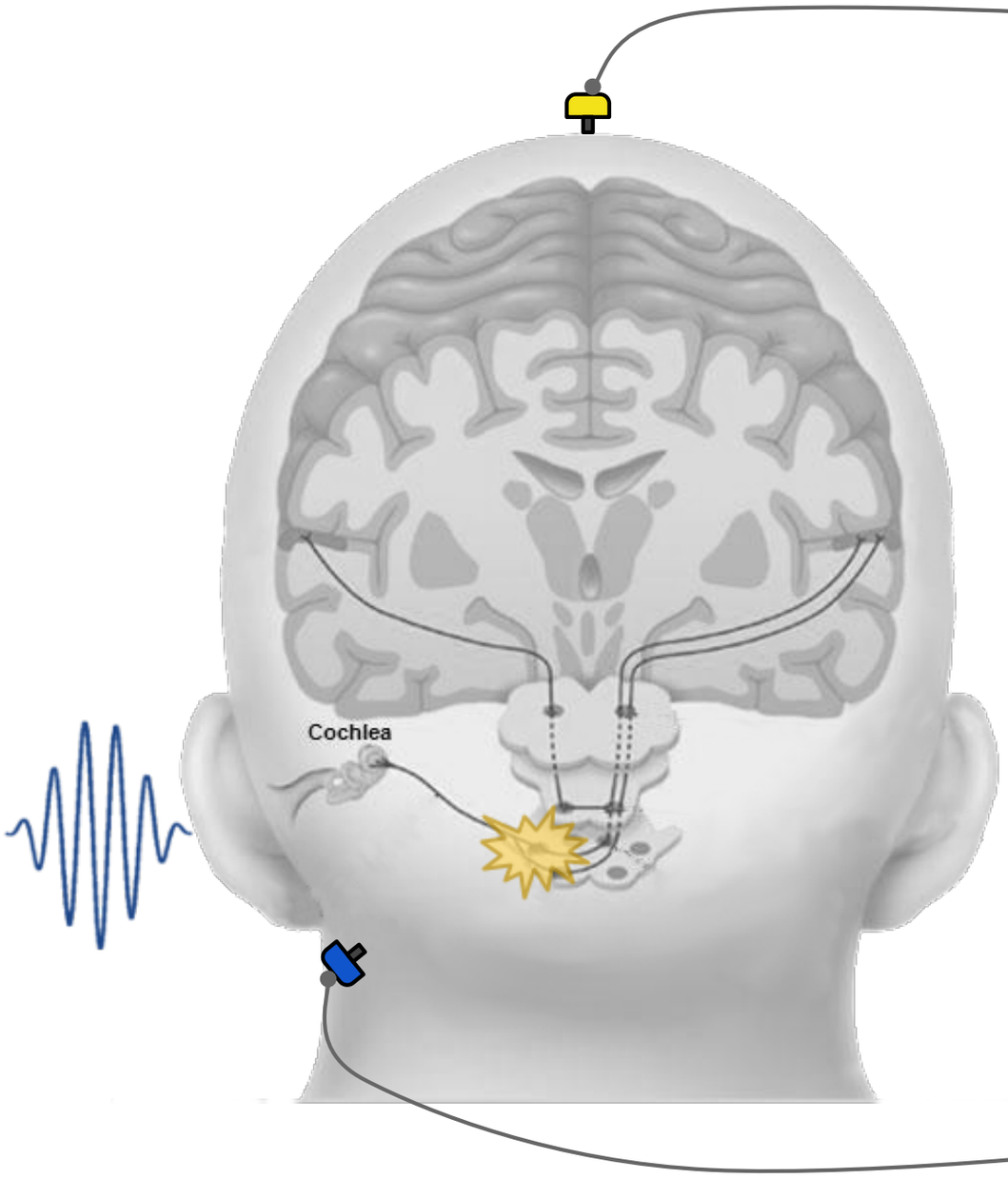
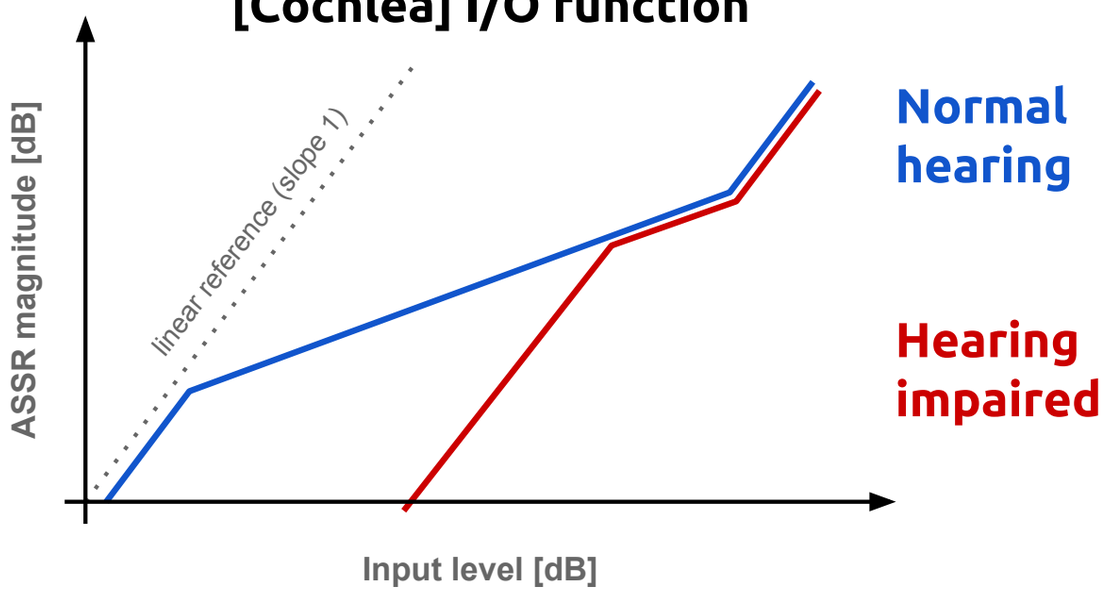
Is it possible to estimate **peripheral compression** using **ASSR**?





Results: A representative NH subject (N=13)

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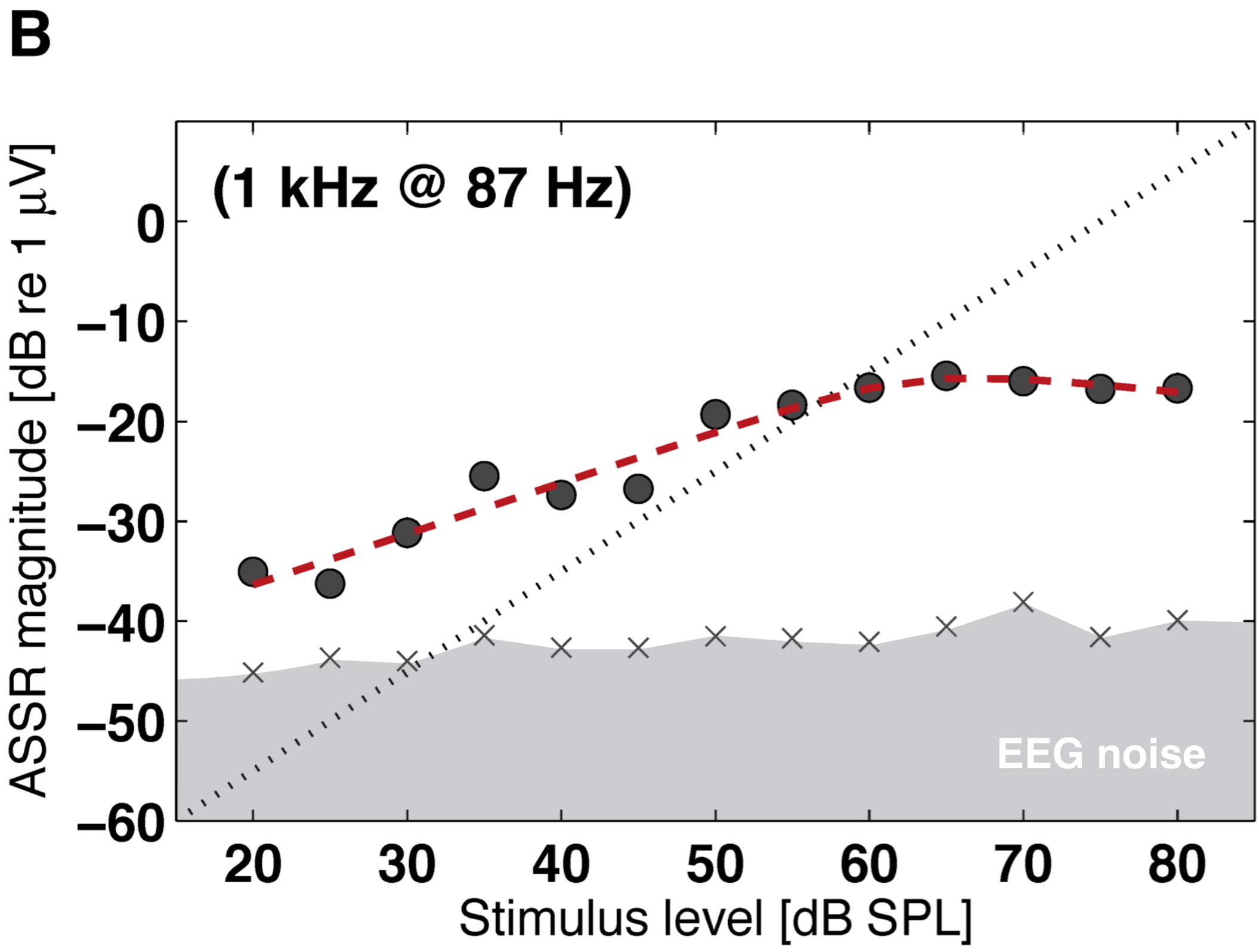

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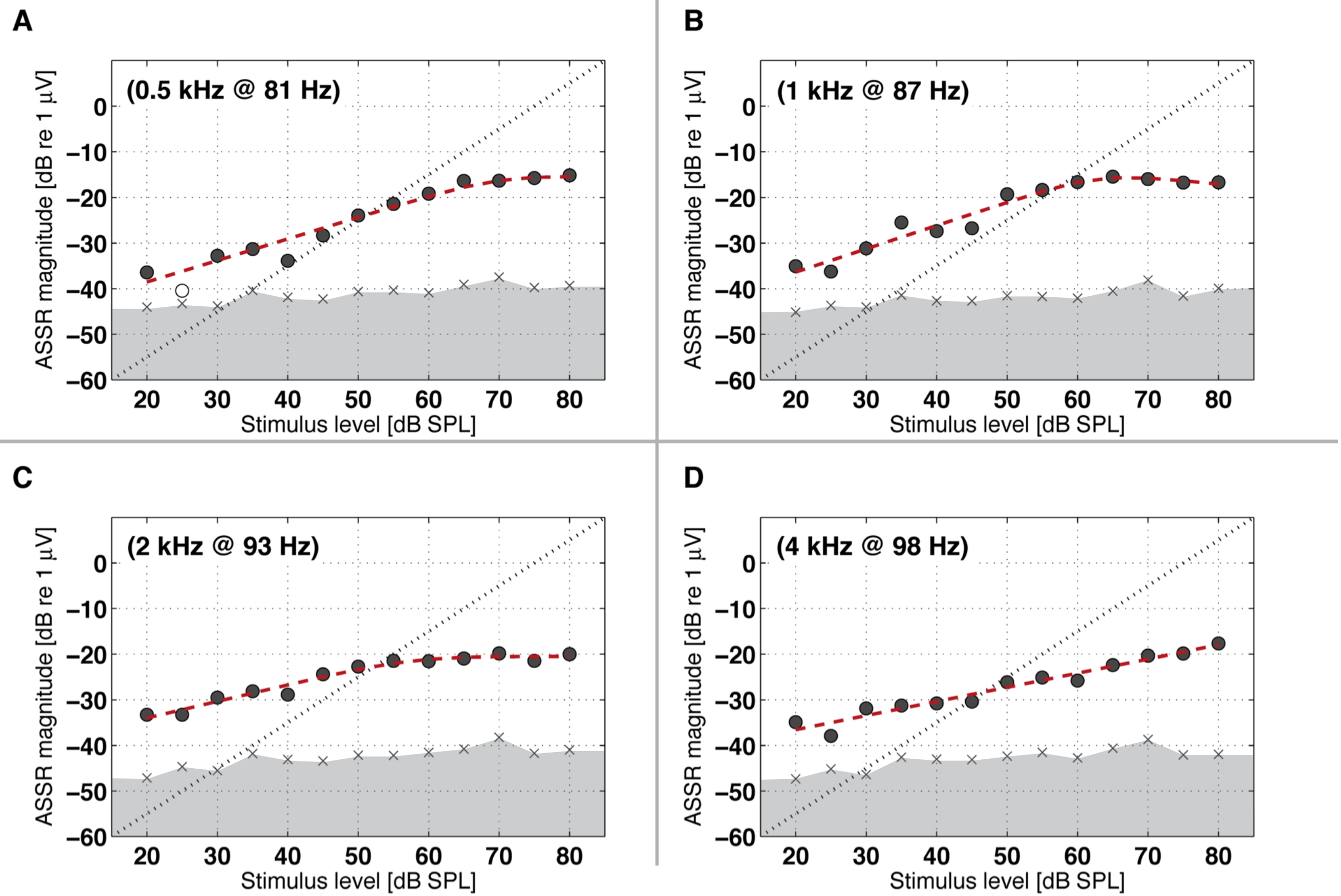

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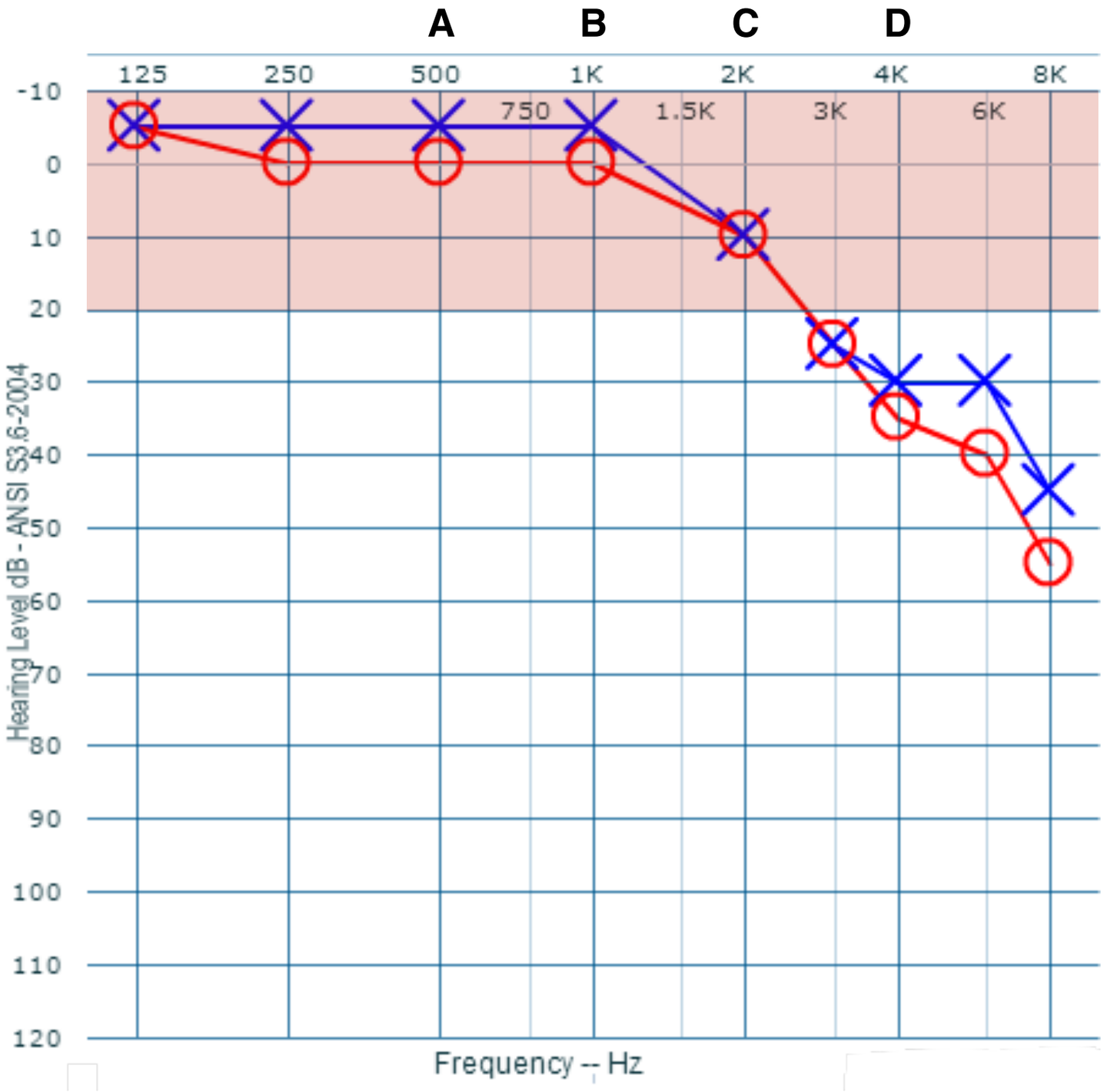

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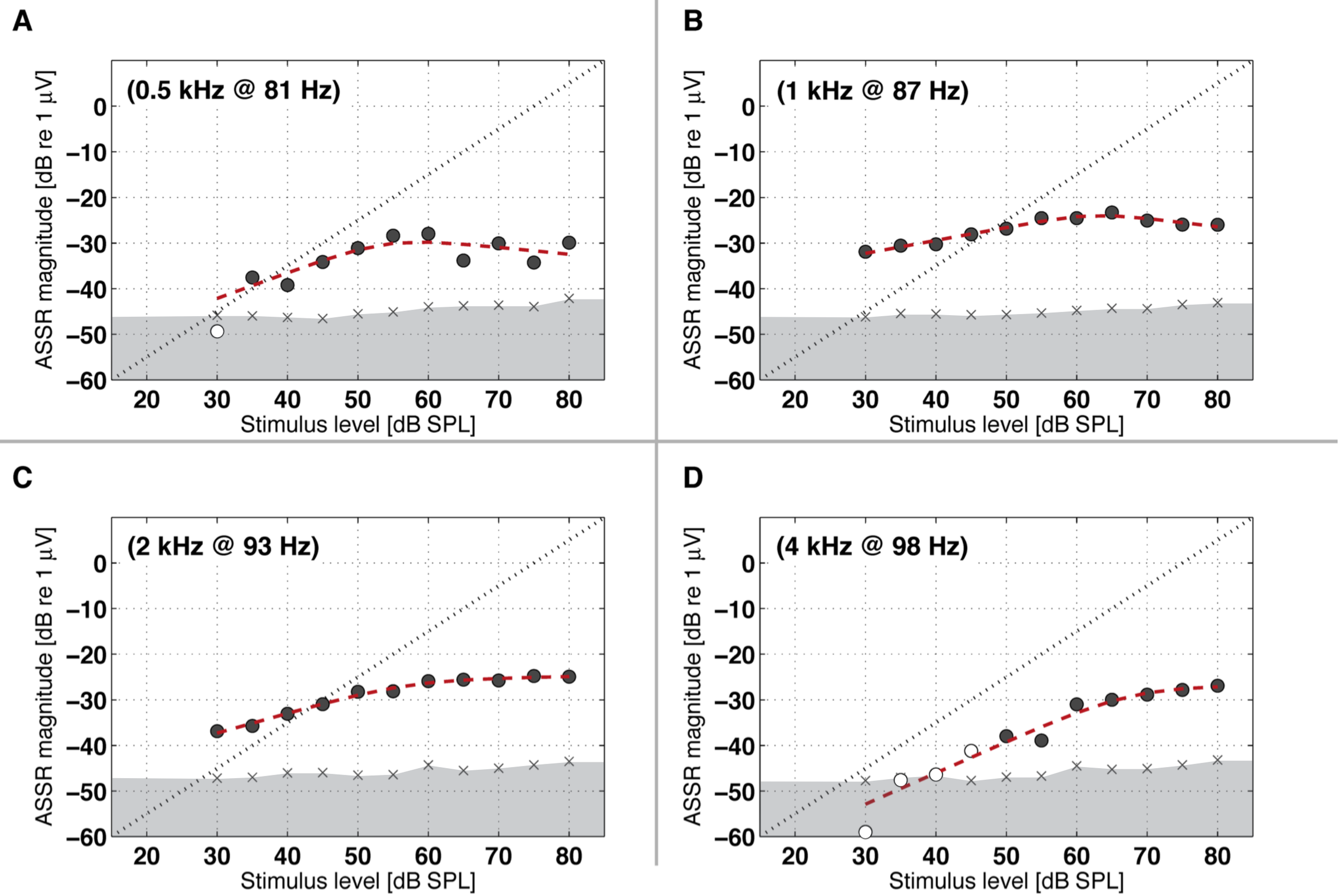

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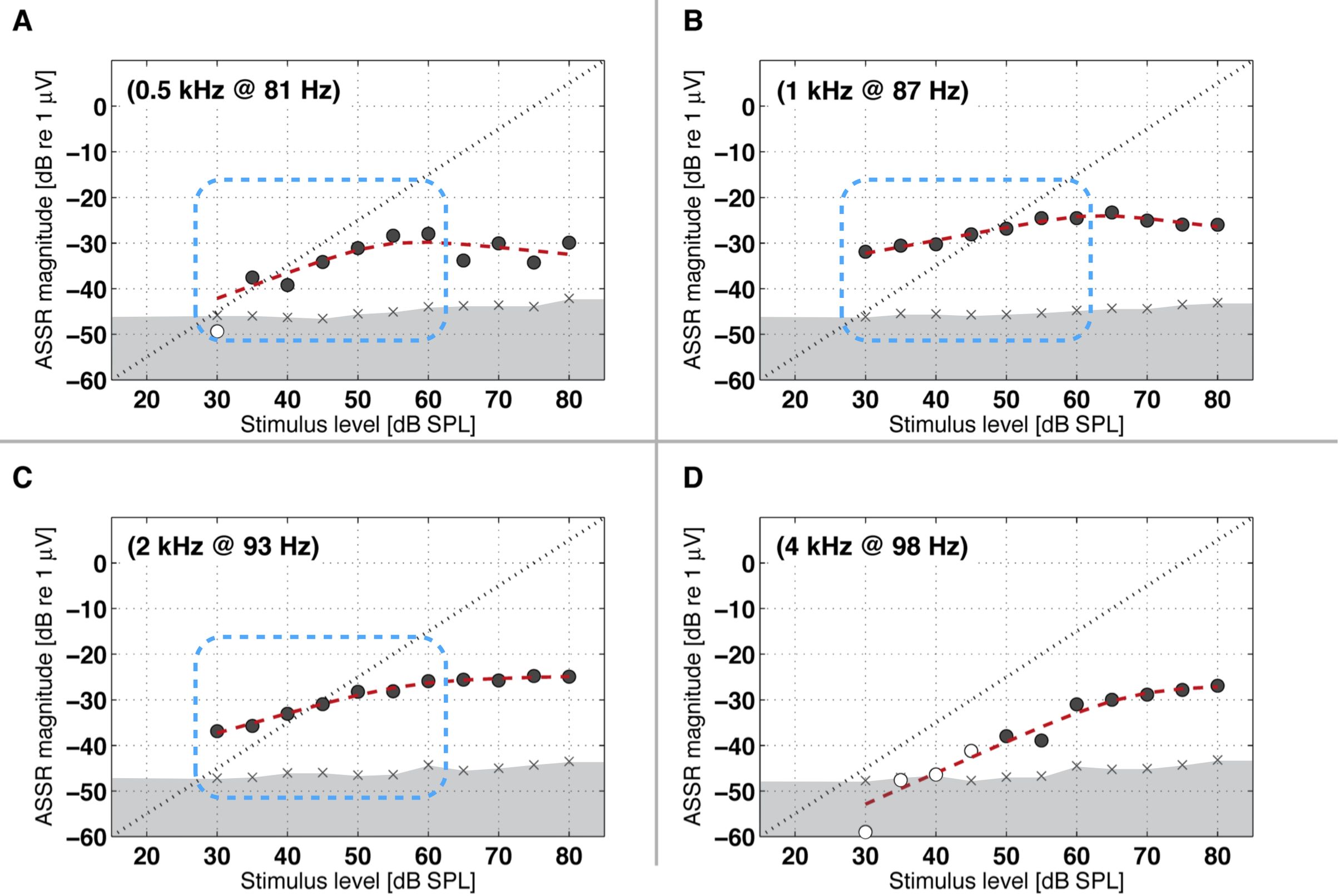

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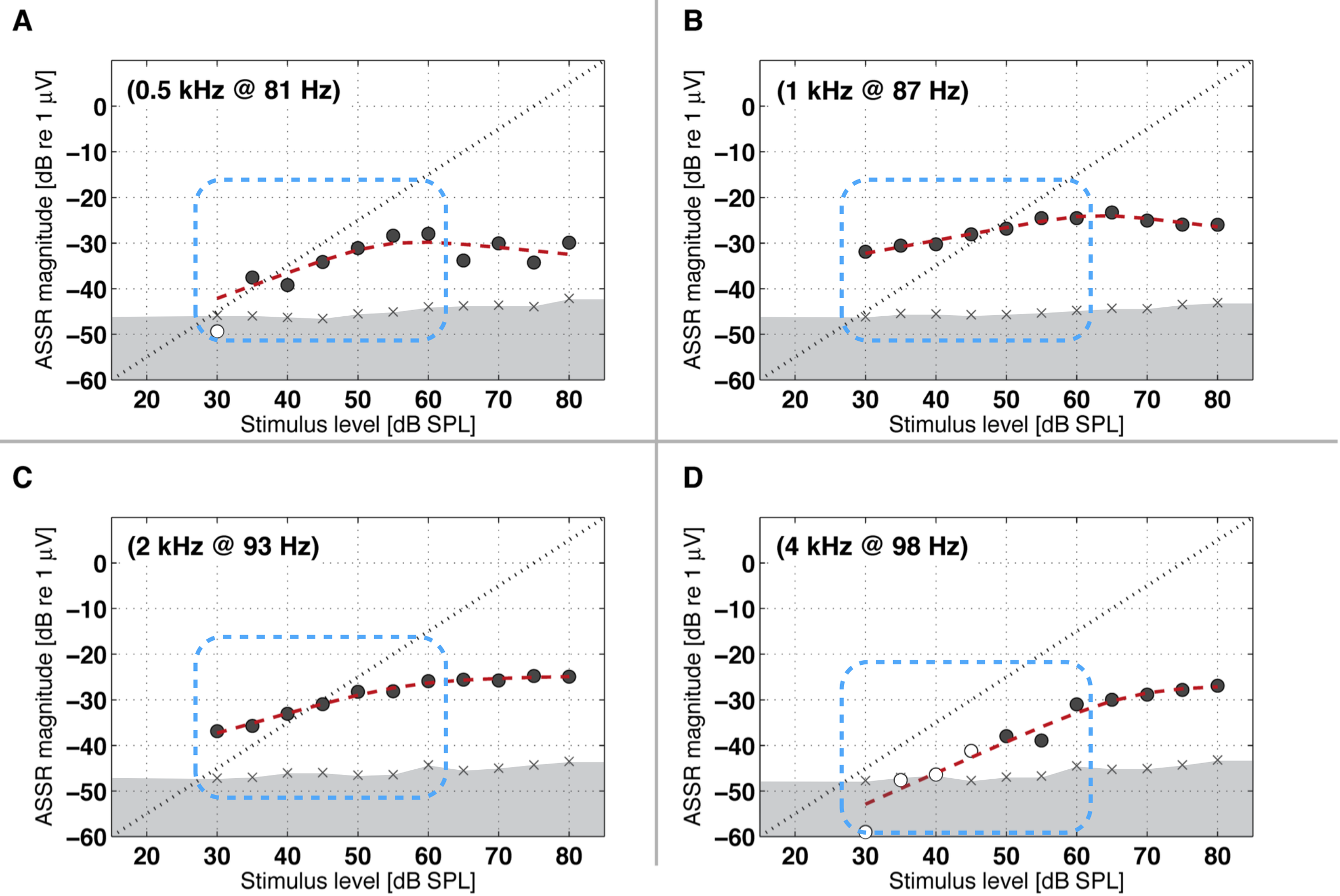

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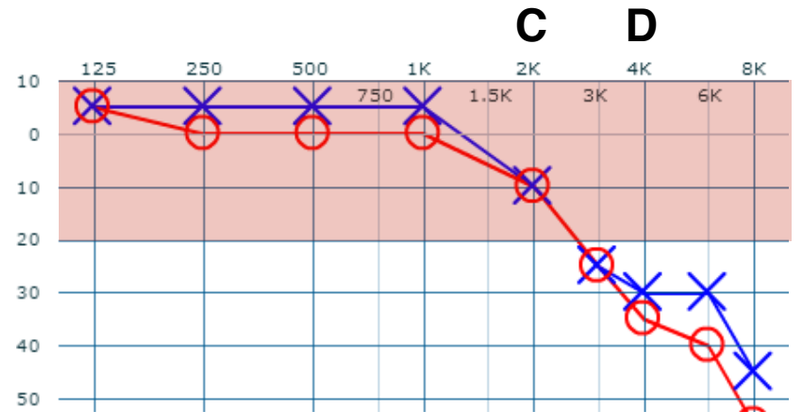
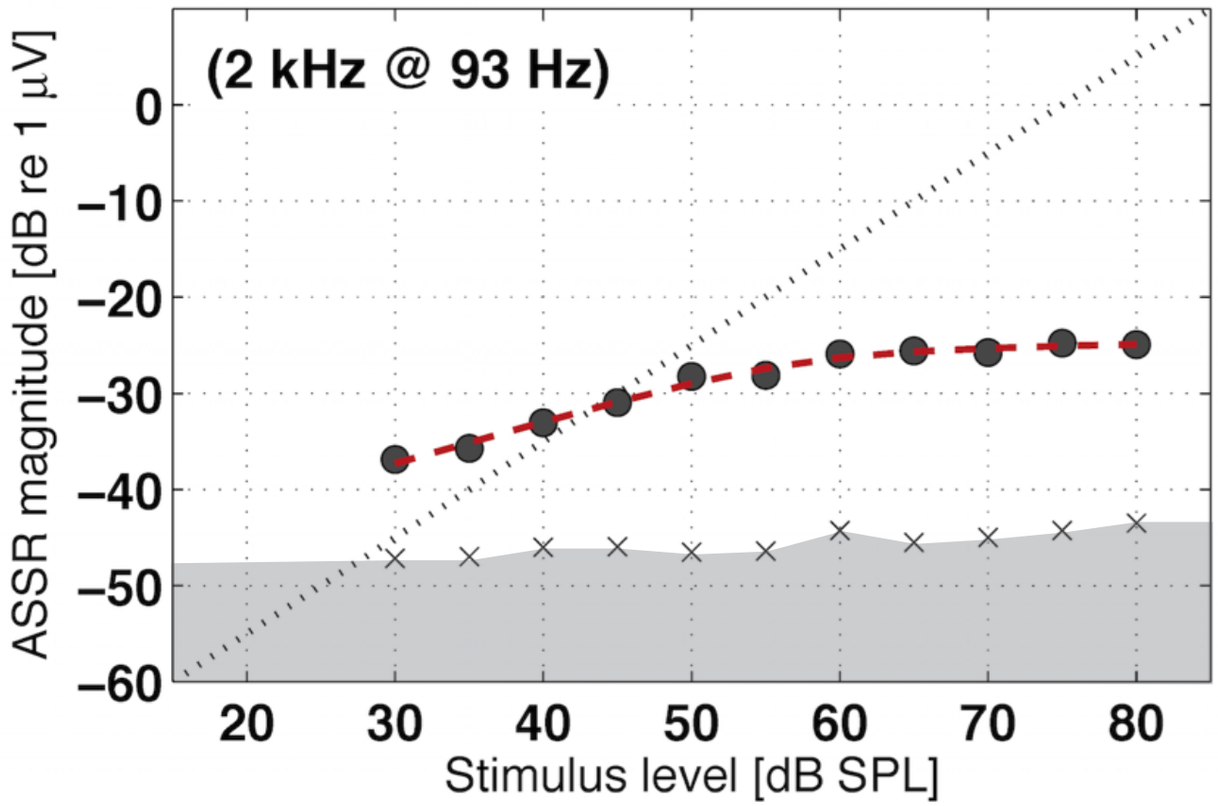
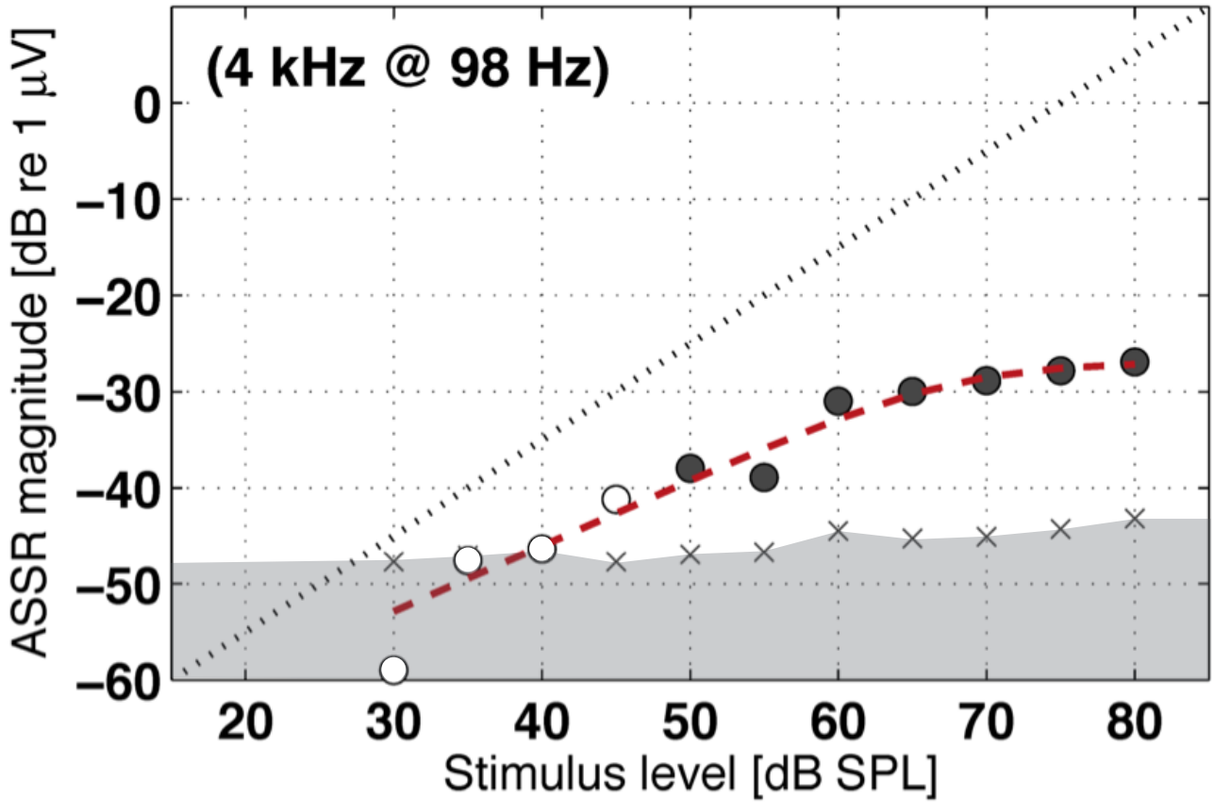


C



NH

D



HI

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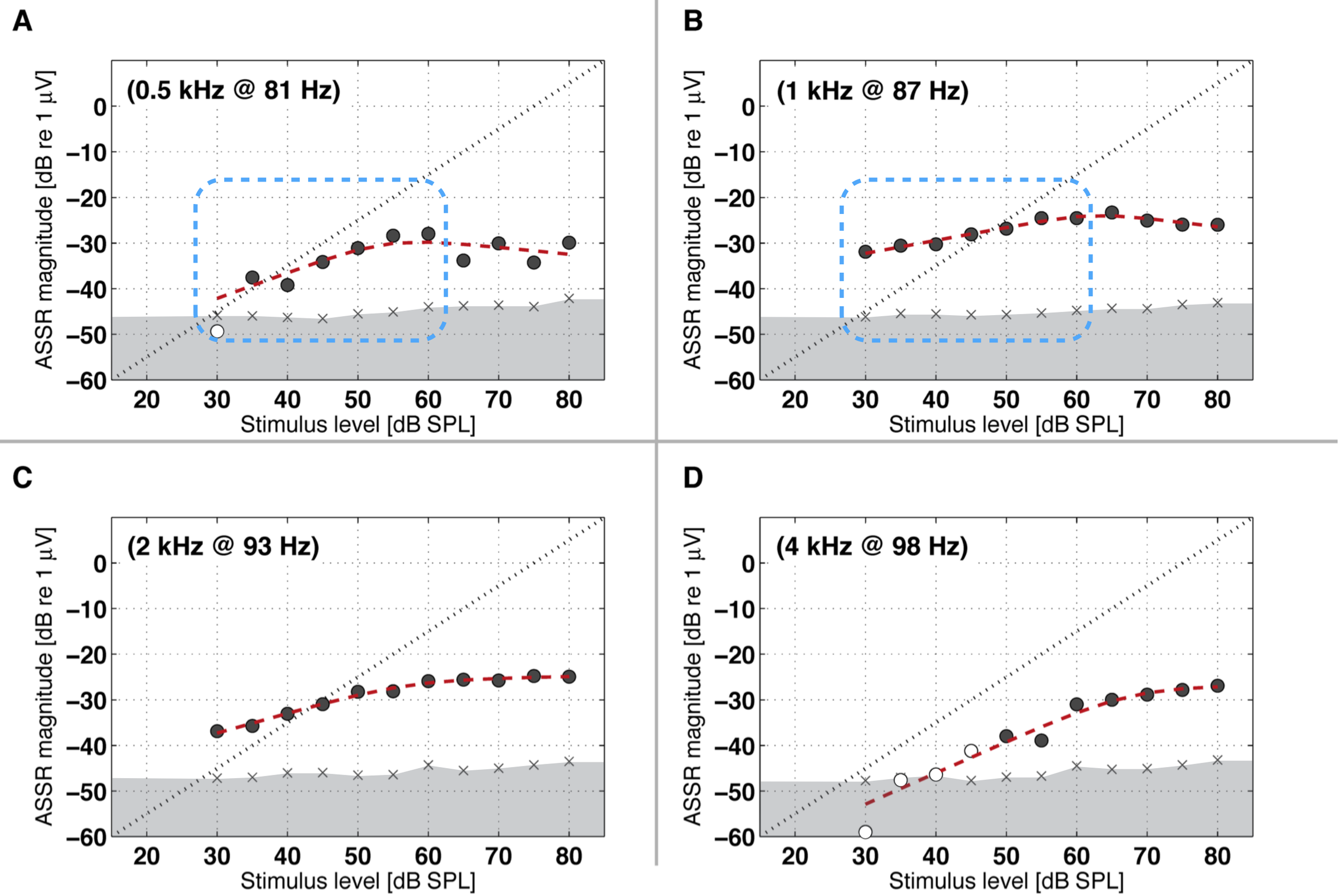

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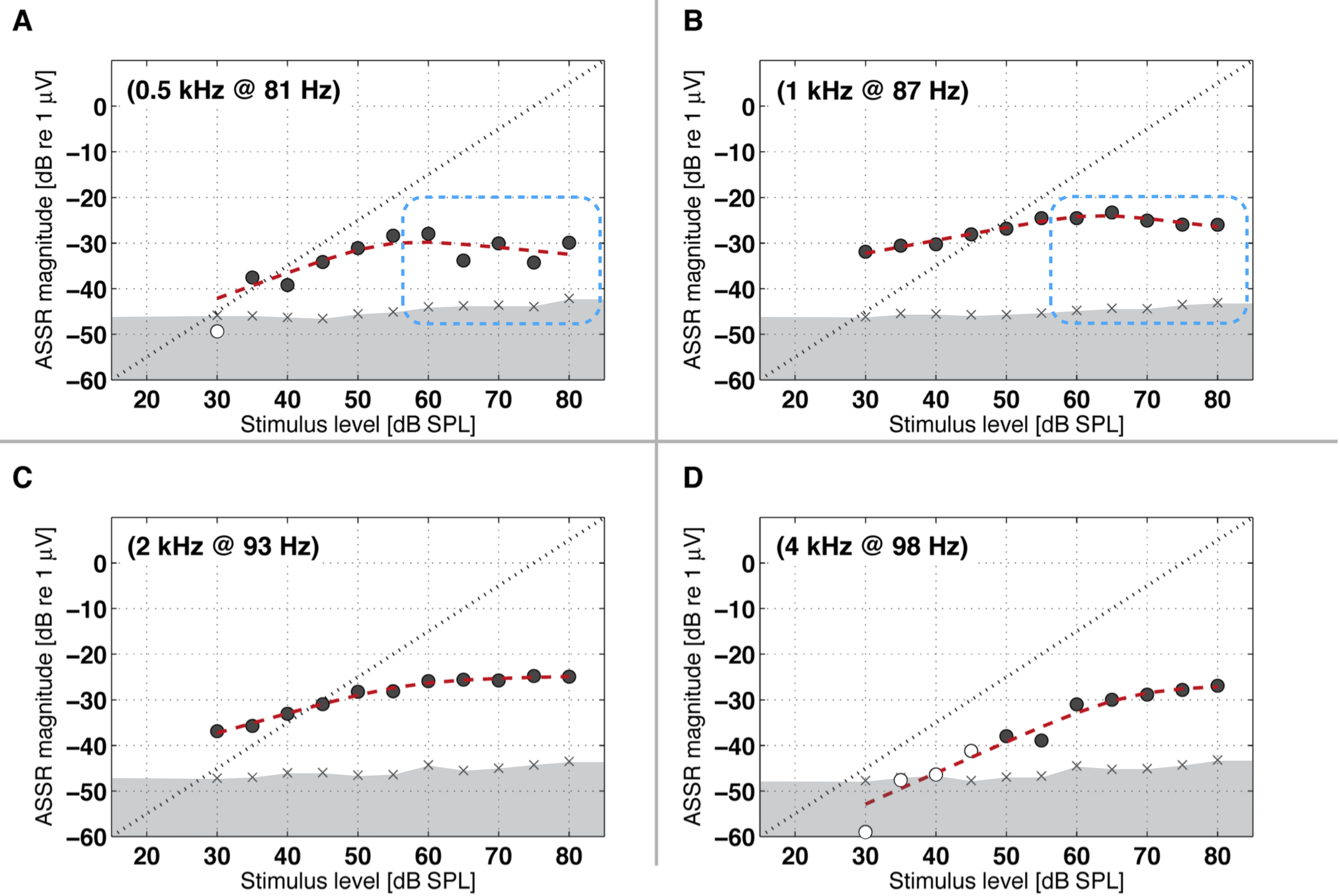

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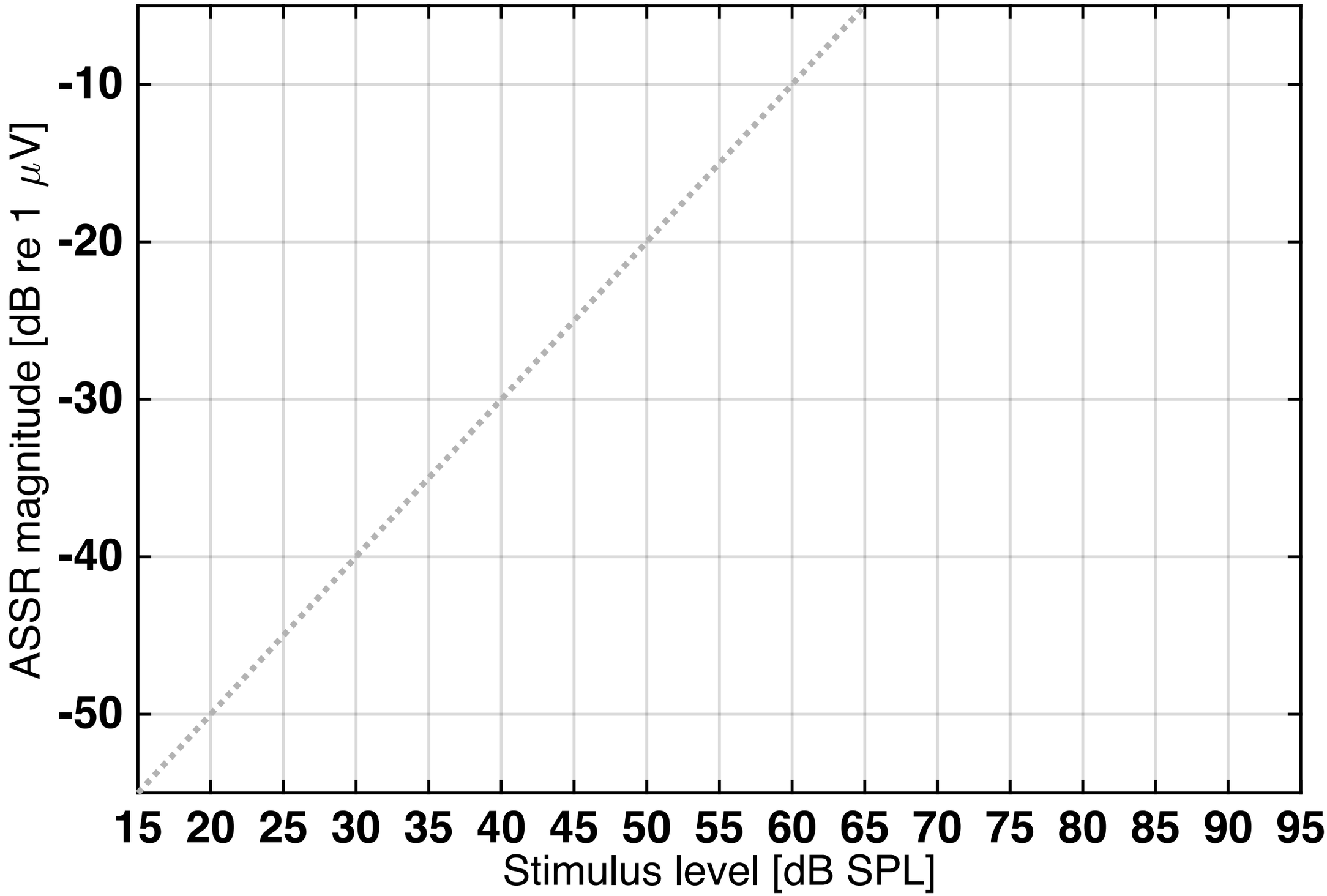

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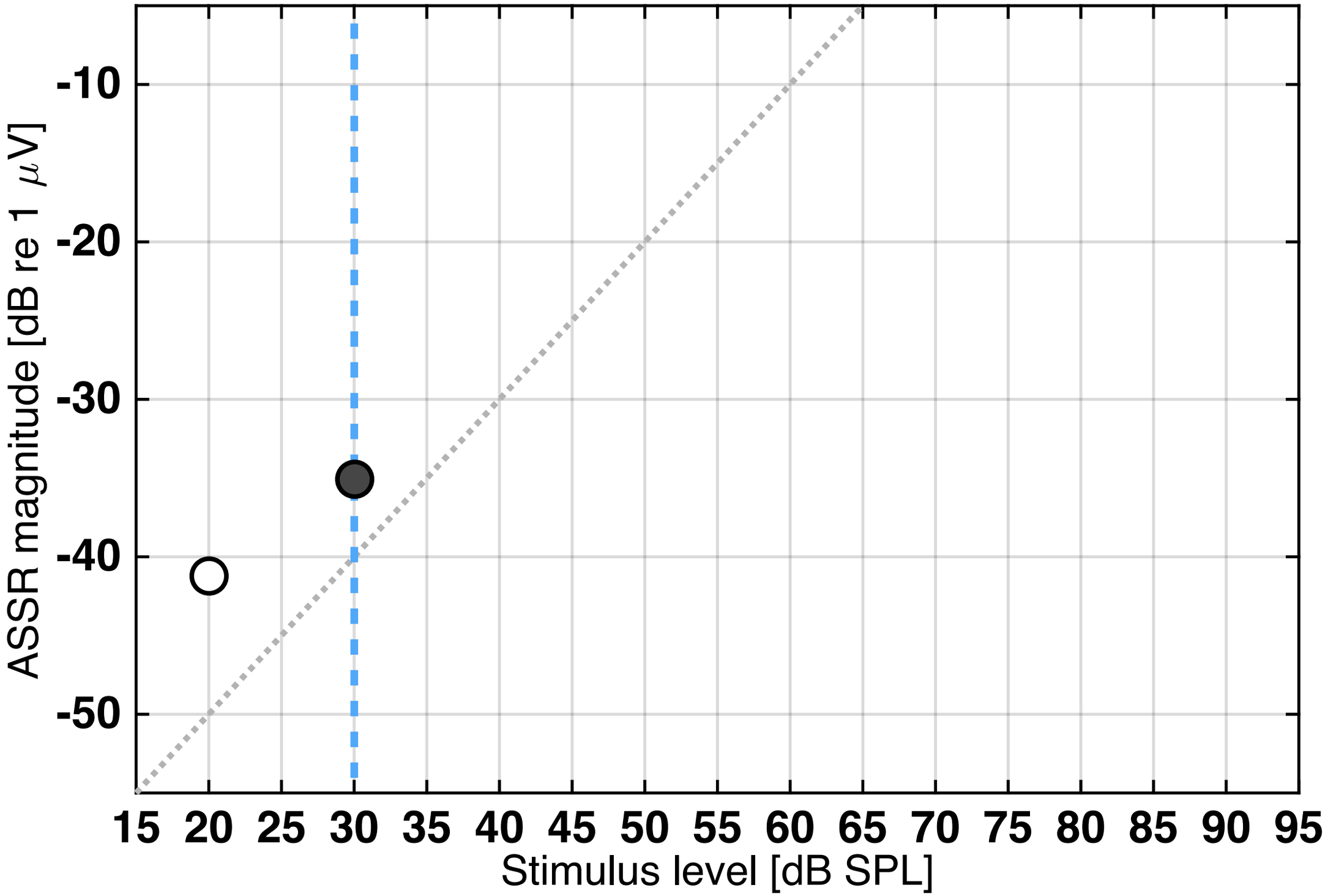

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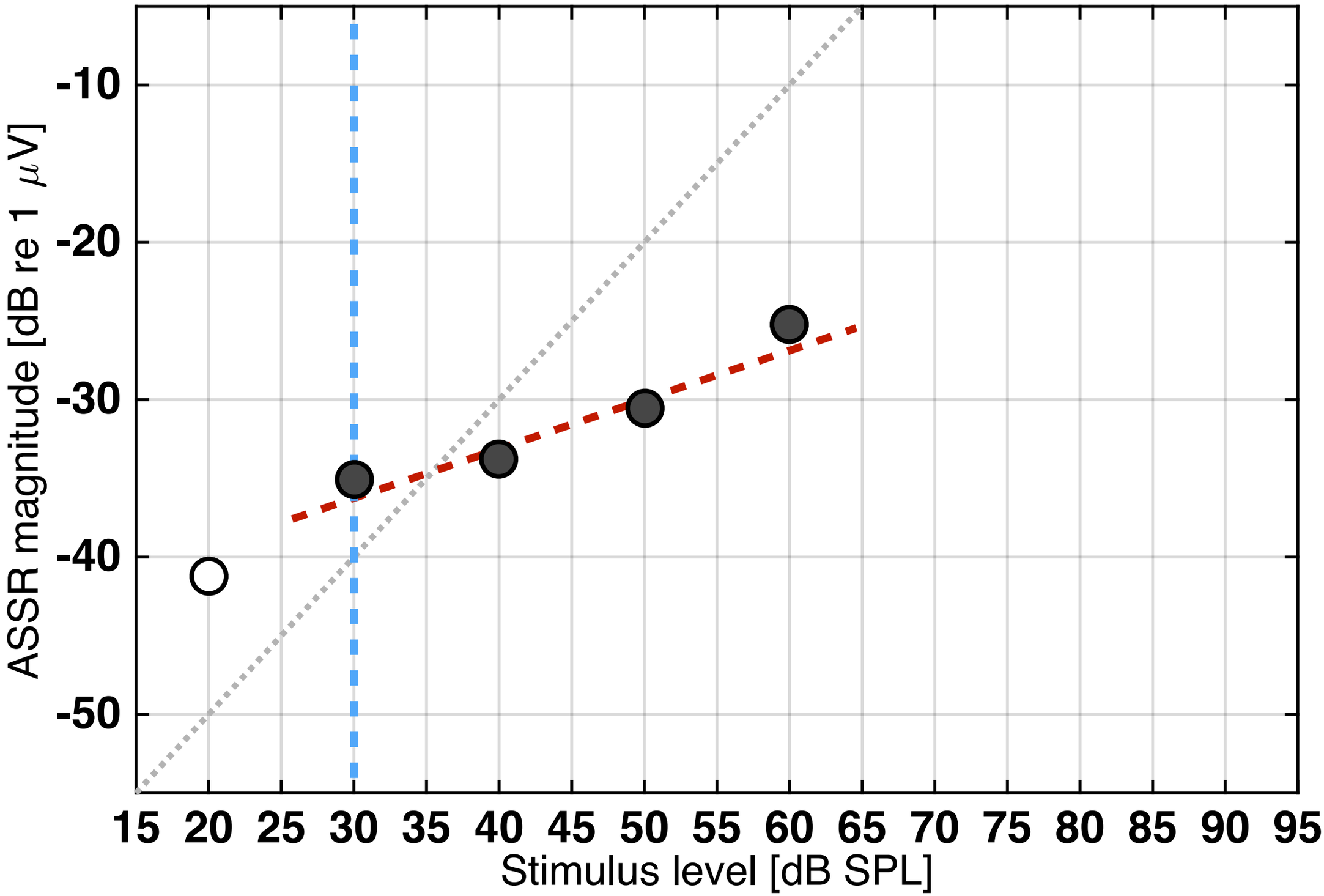

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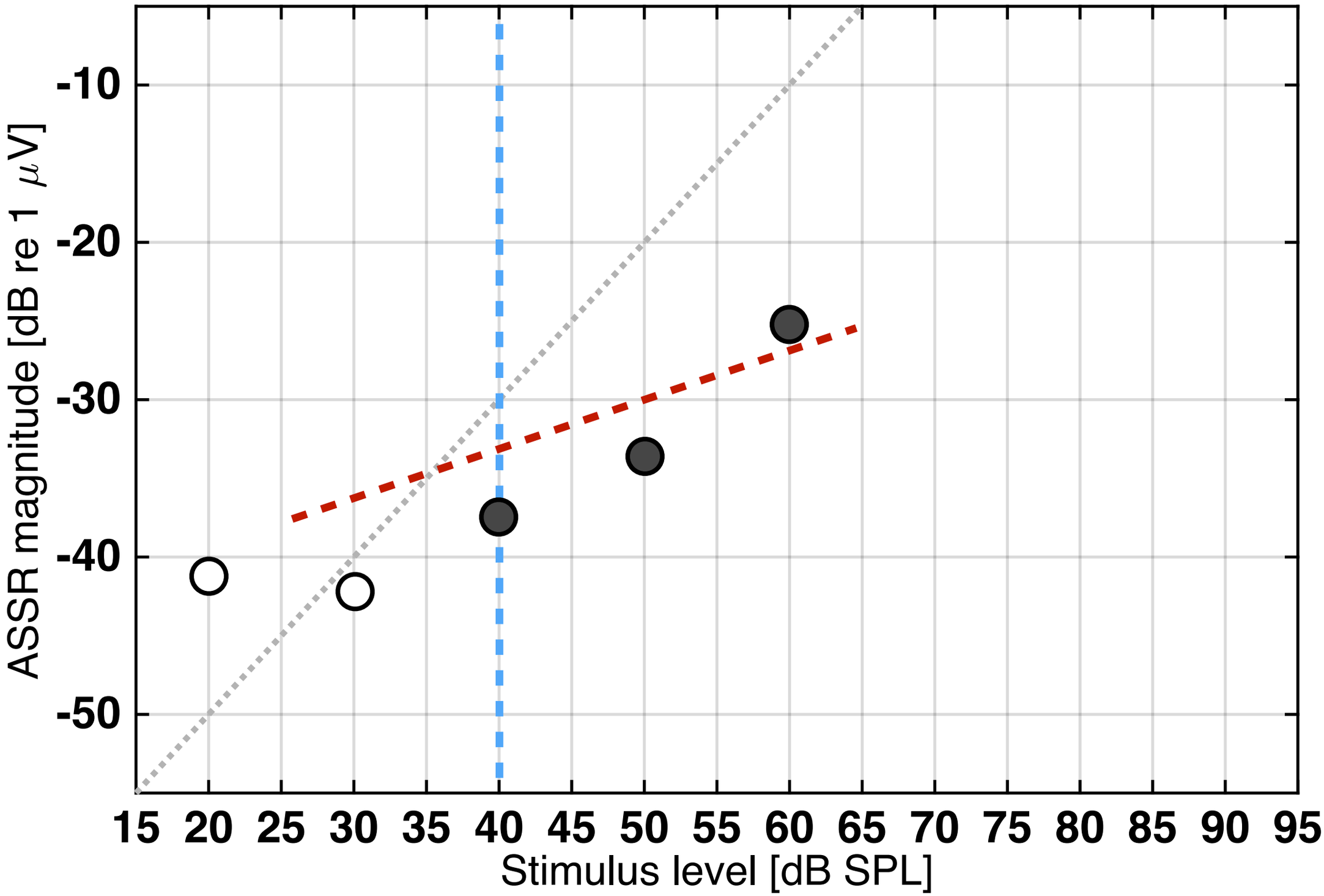

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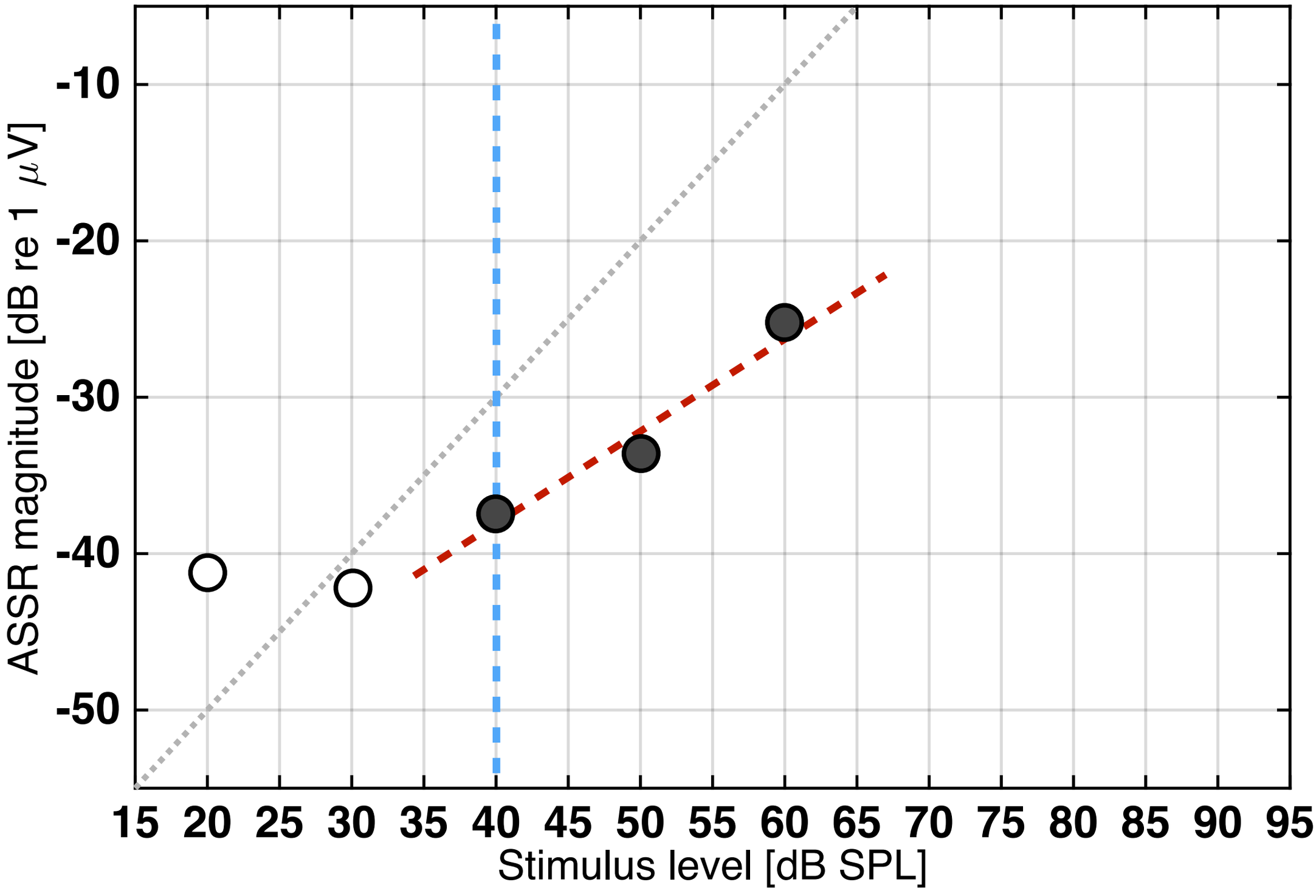

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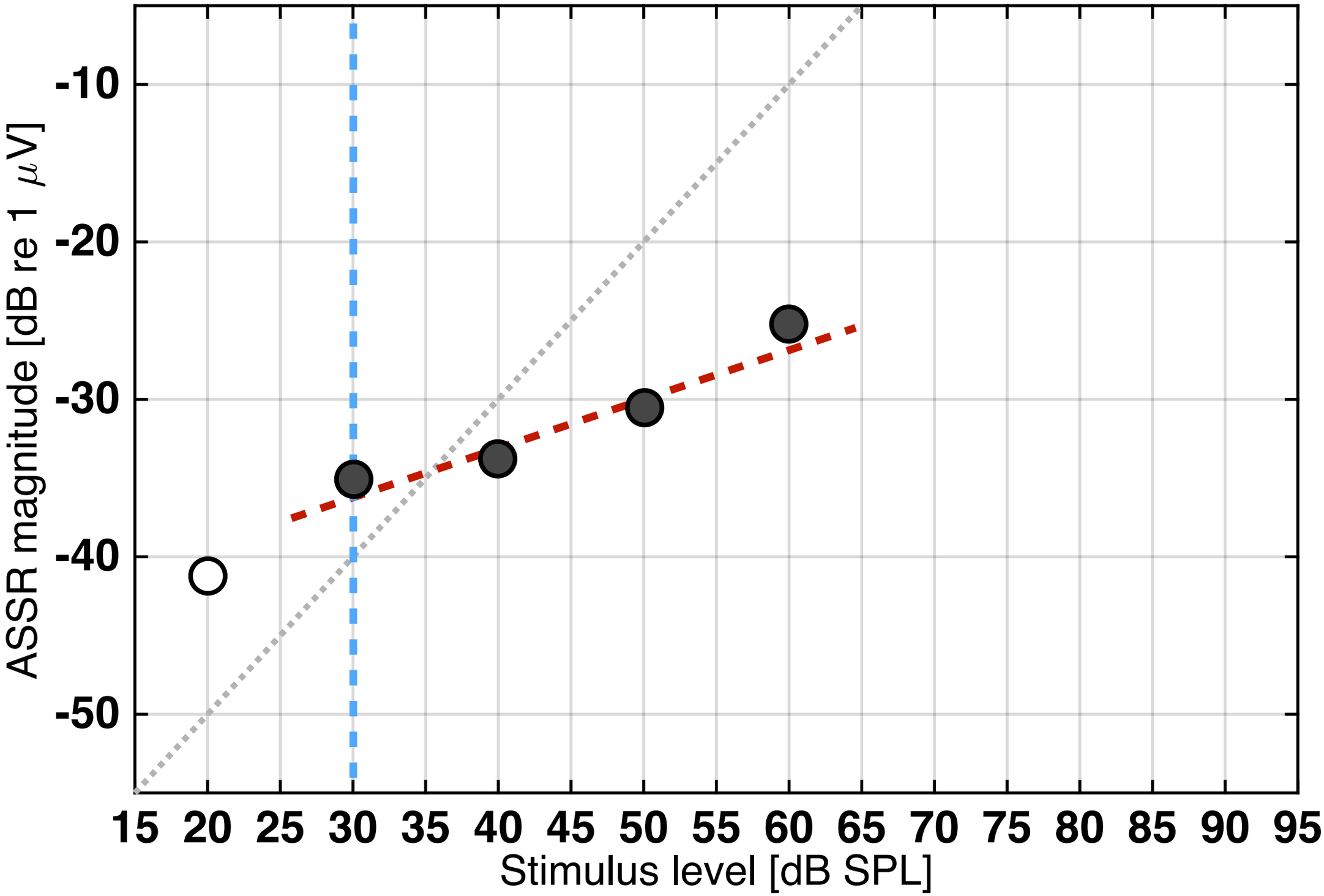

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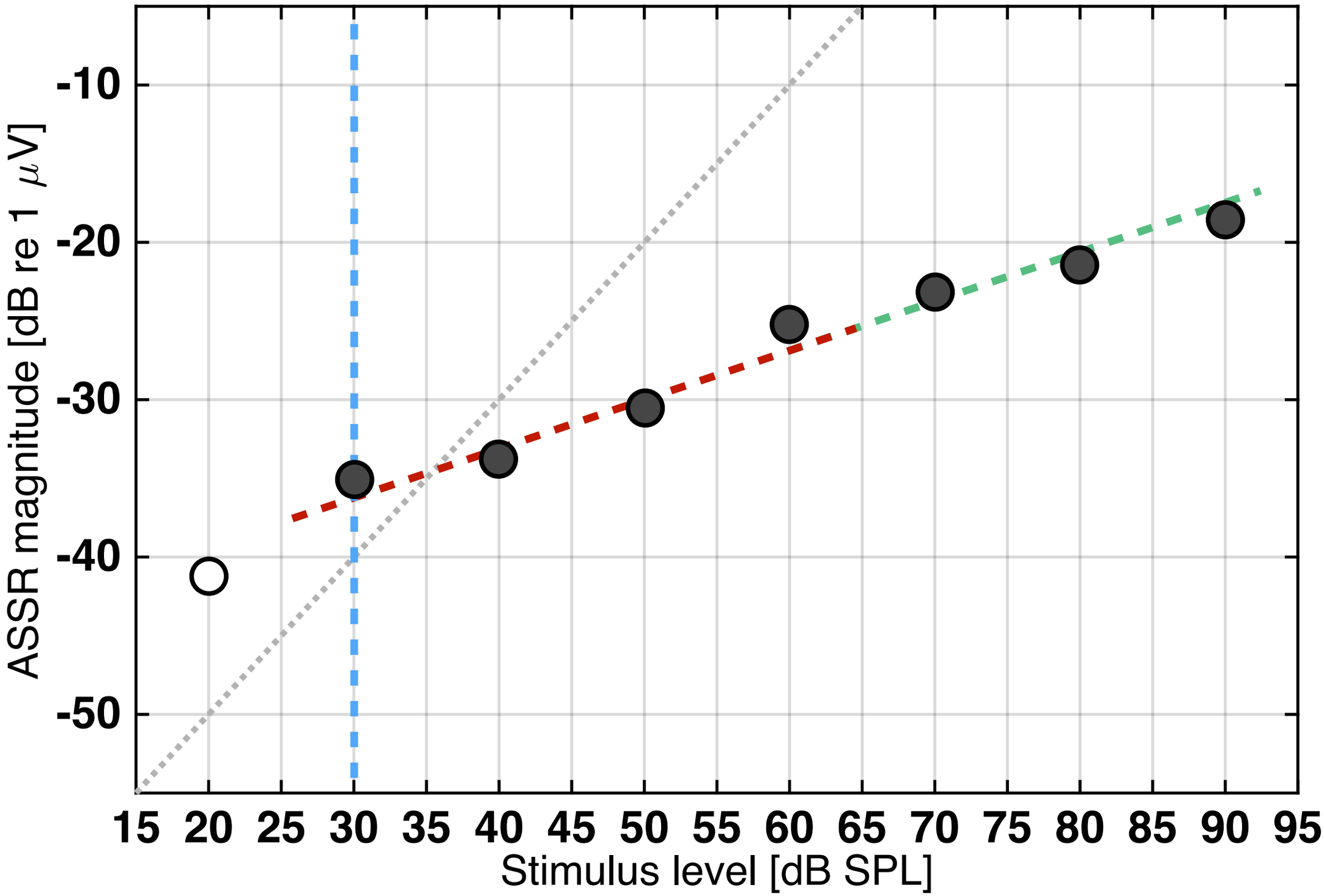

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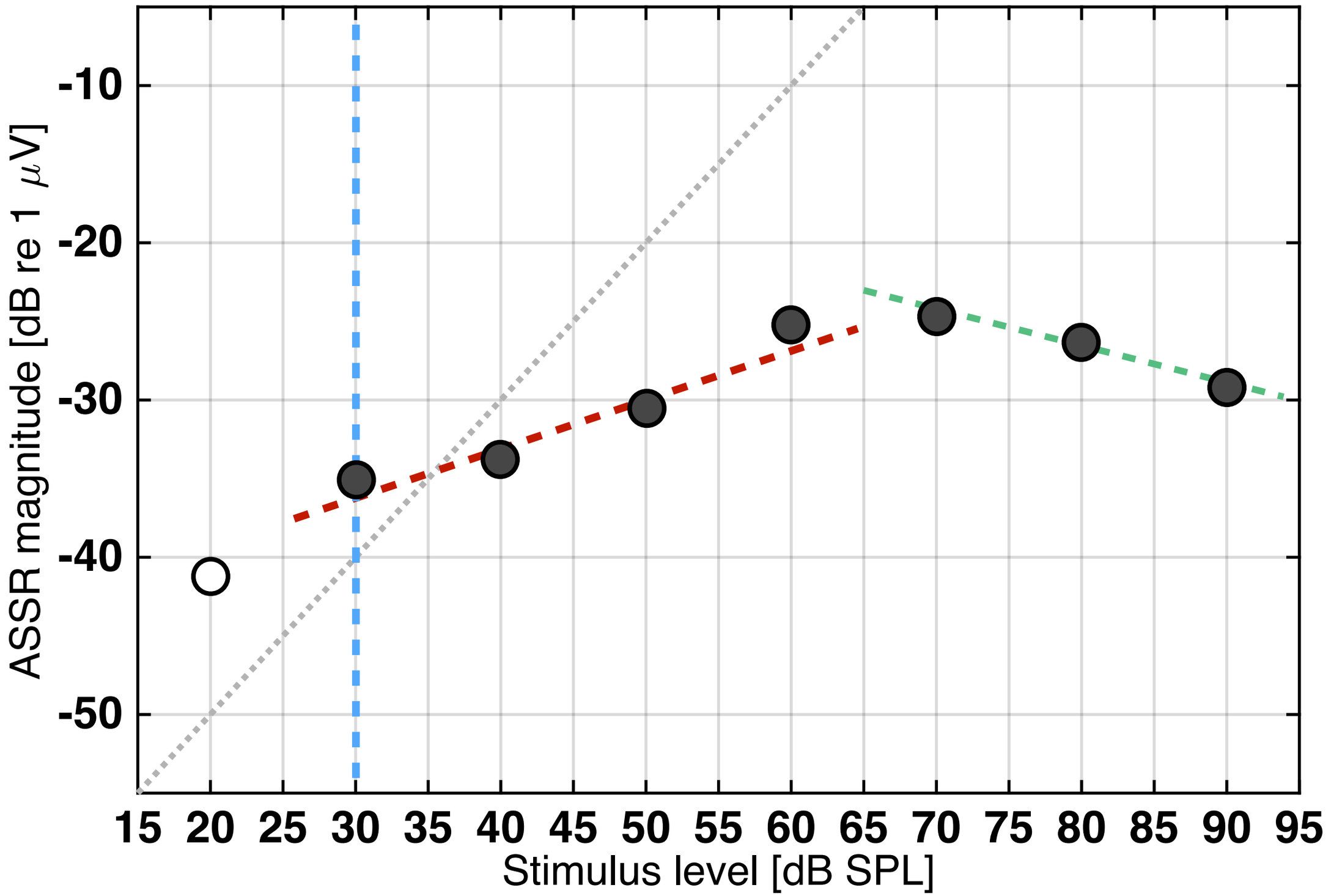

Contribution of SR fibers to deafferentation

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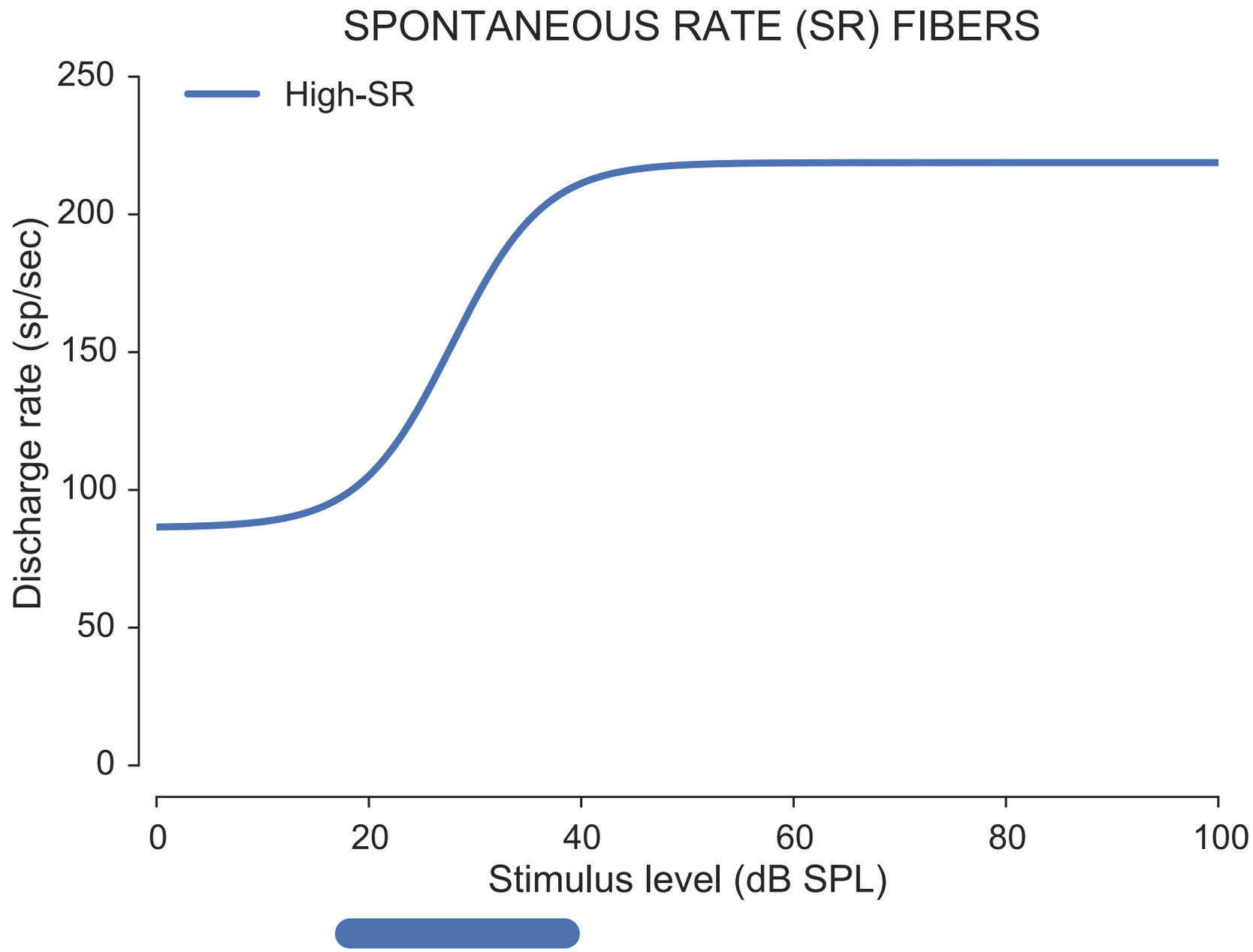
Liberman (1978)

Yates (1990)



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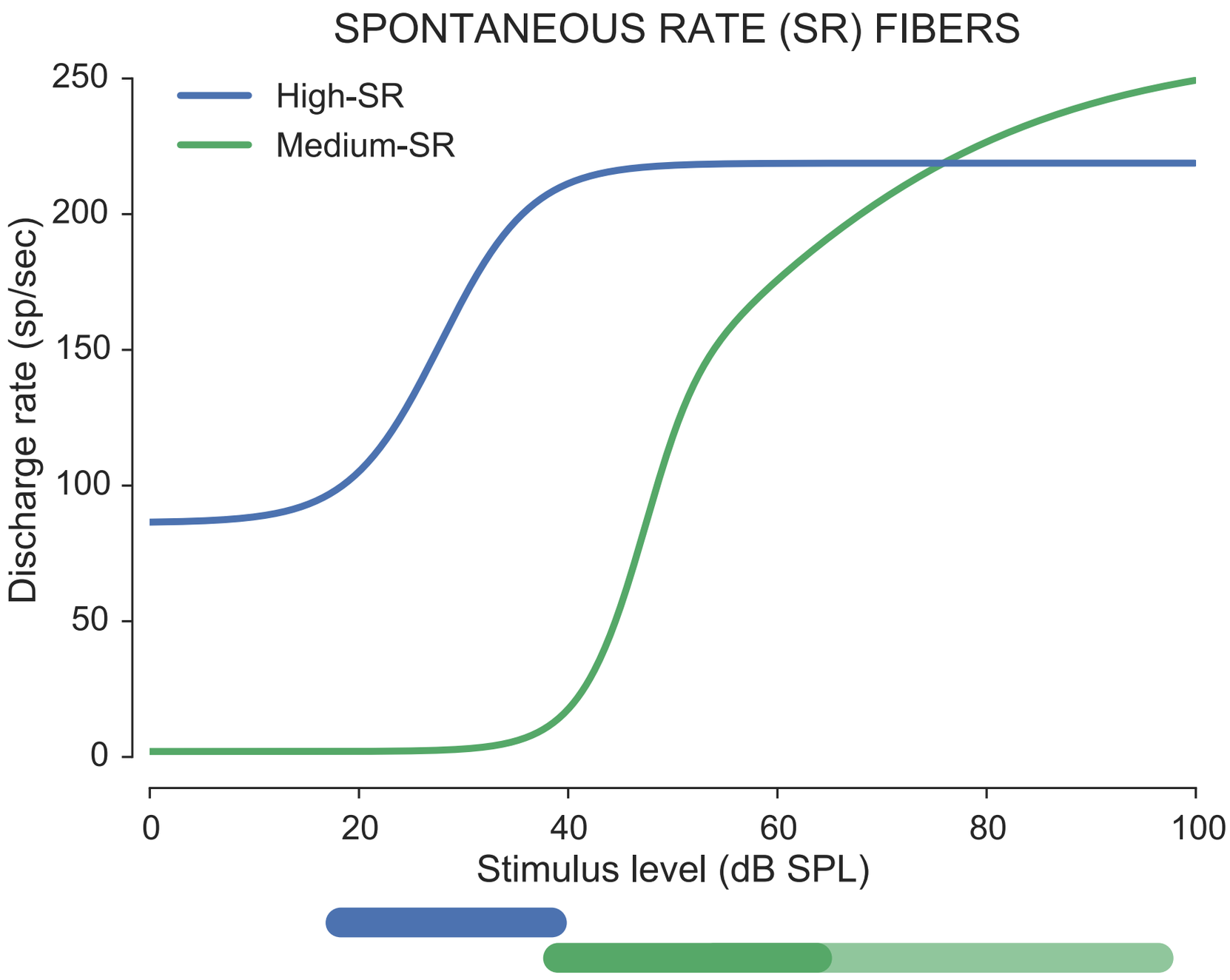

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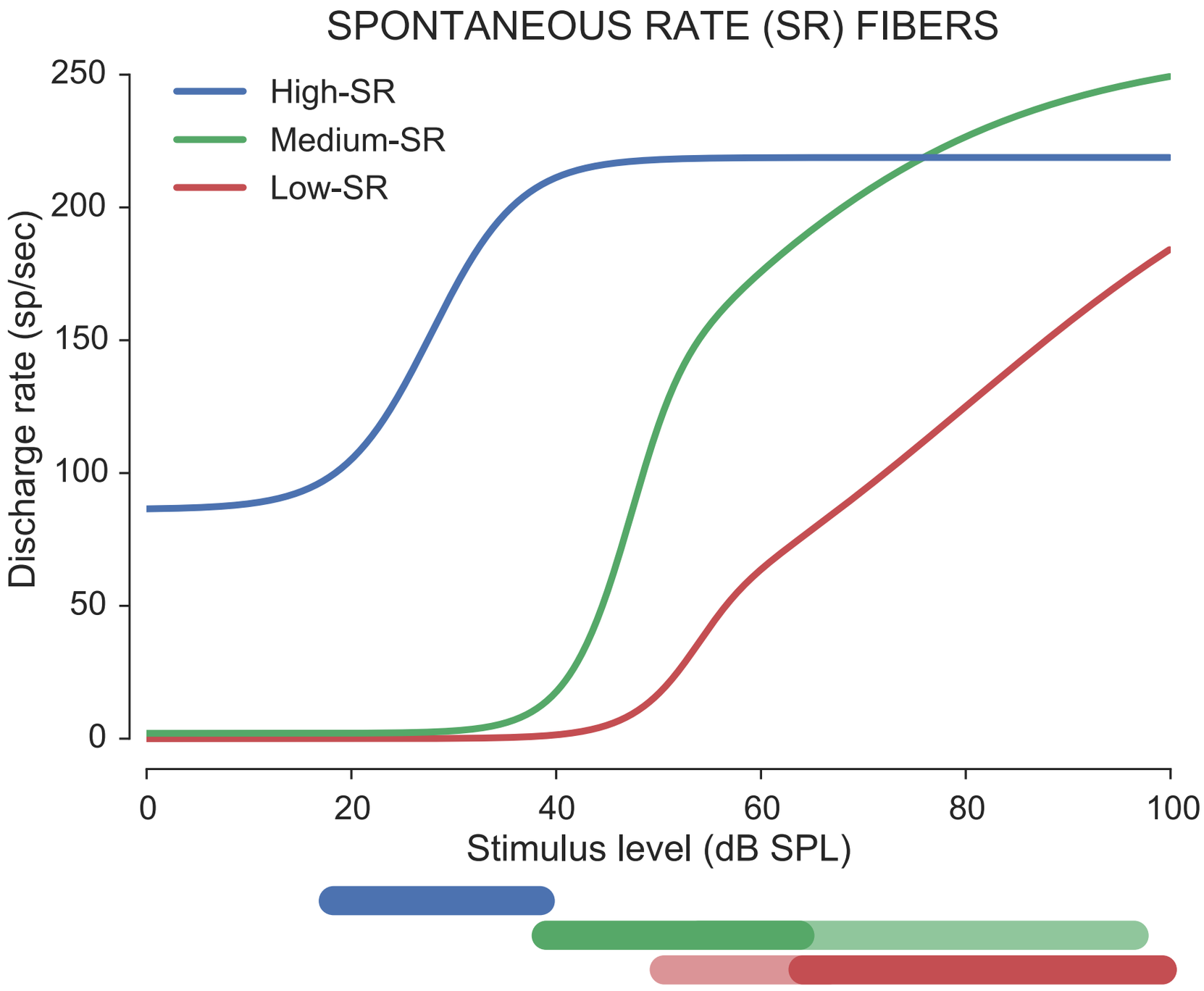

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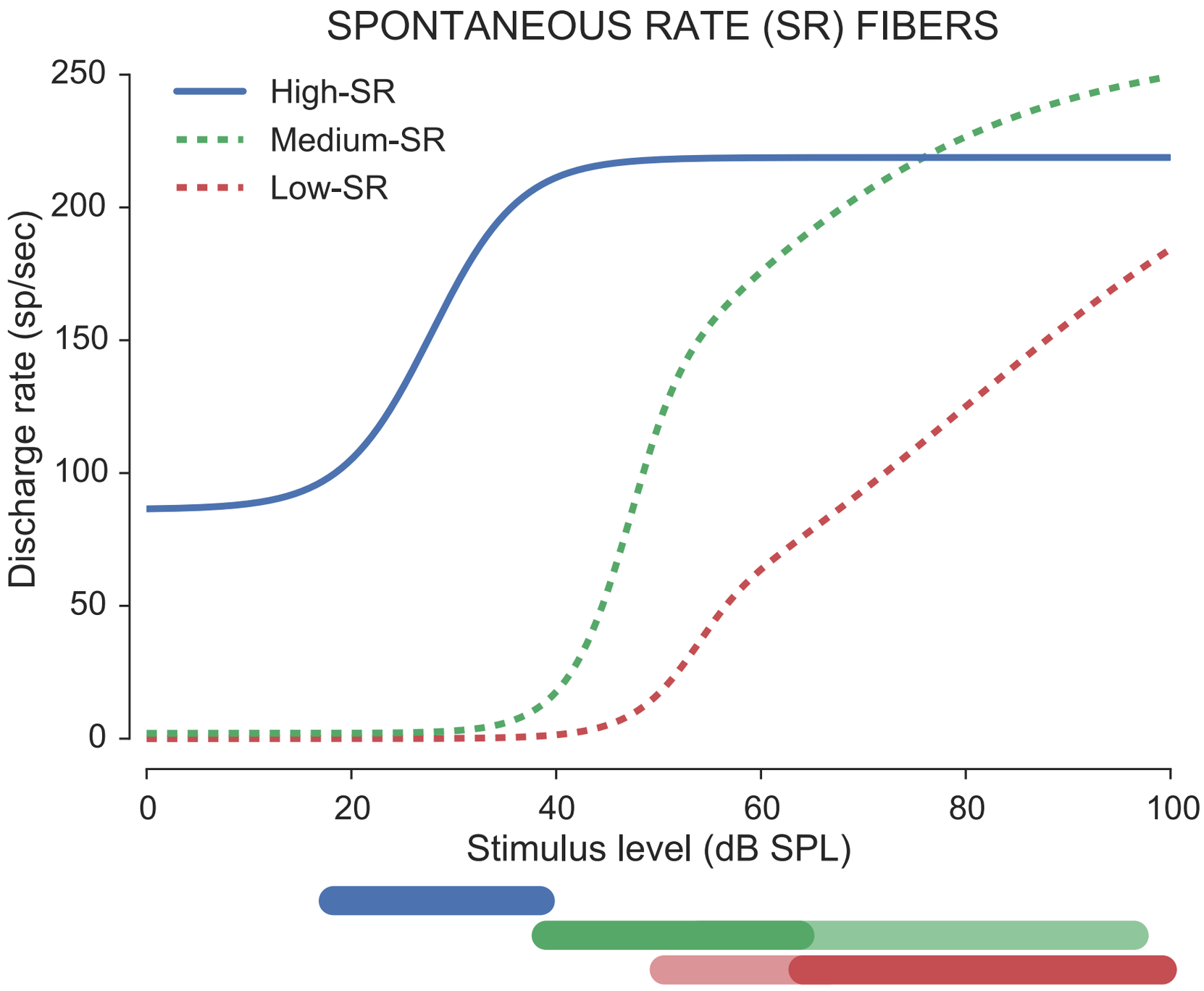
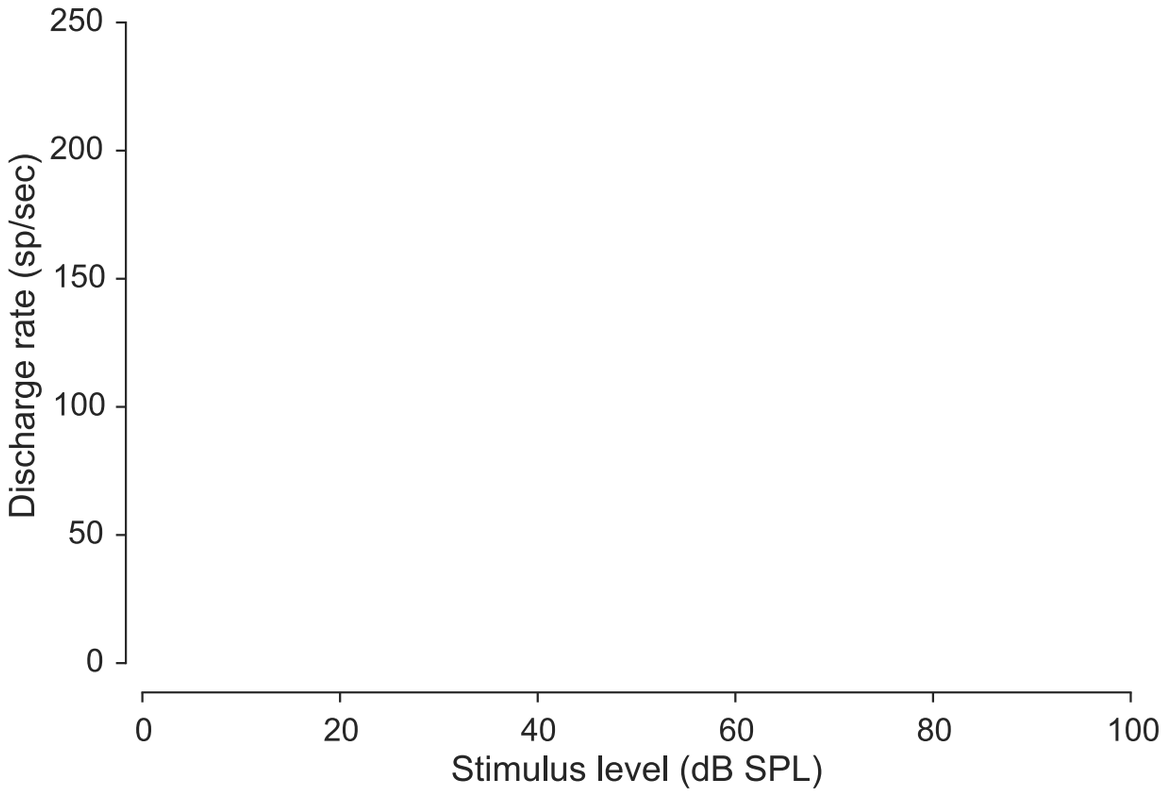
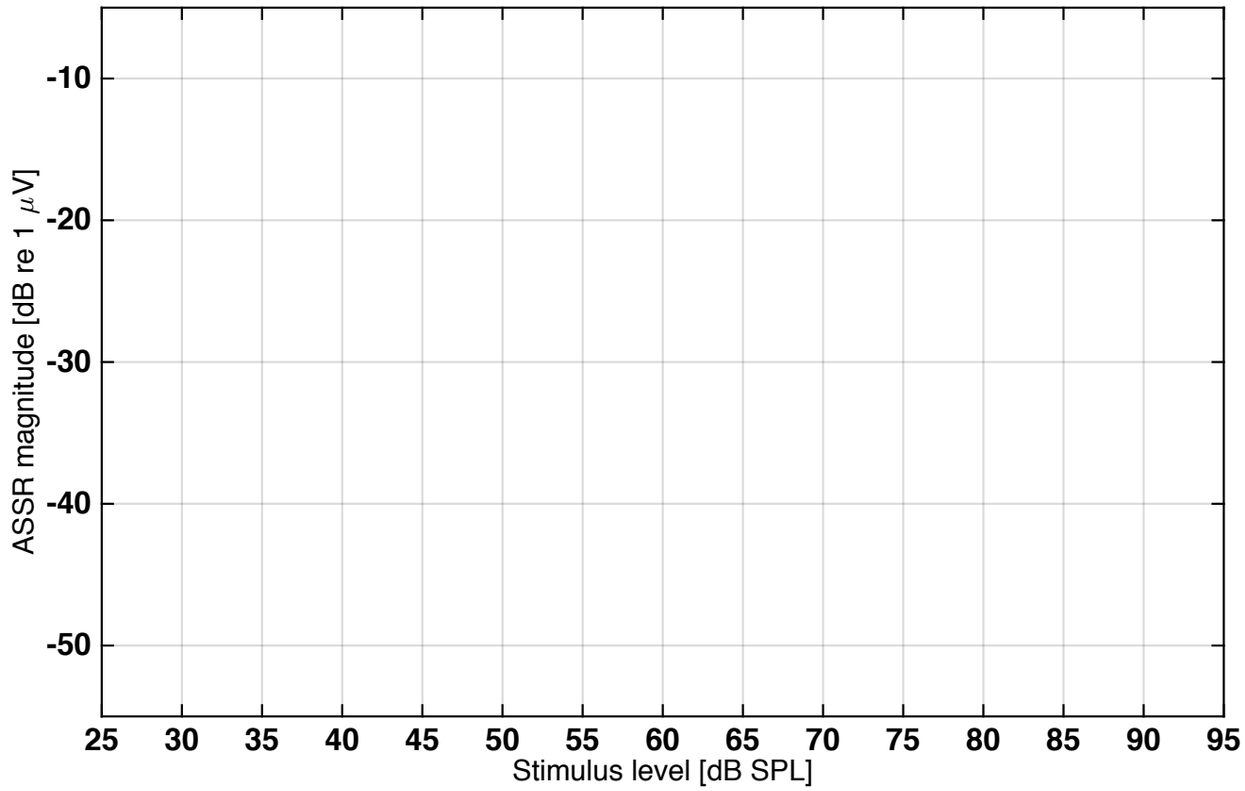


- Furman *et al.* (2013) showed that ANF "**deafferentation**" due to noise over-exposure is more **selective** to **medium-** and **low-SR fibers**

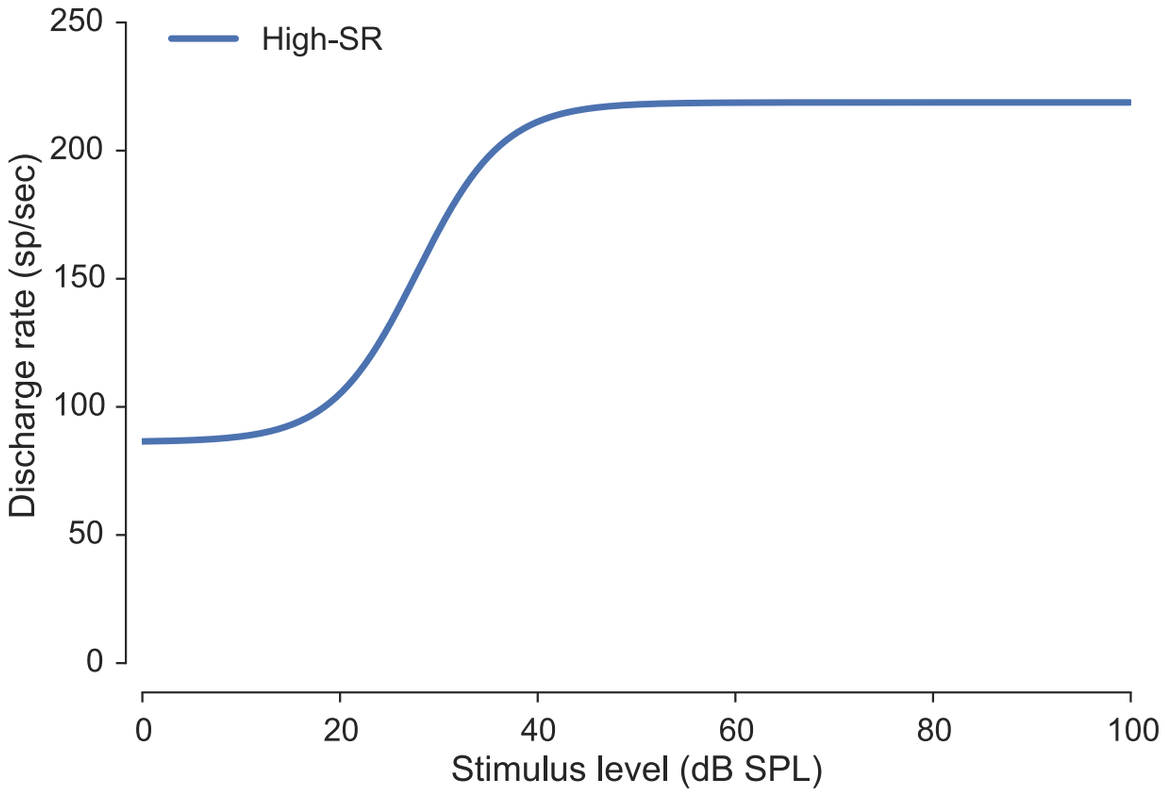
Potential explanation

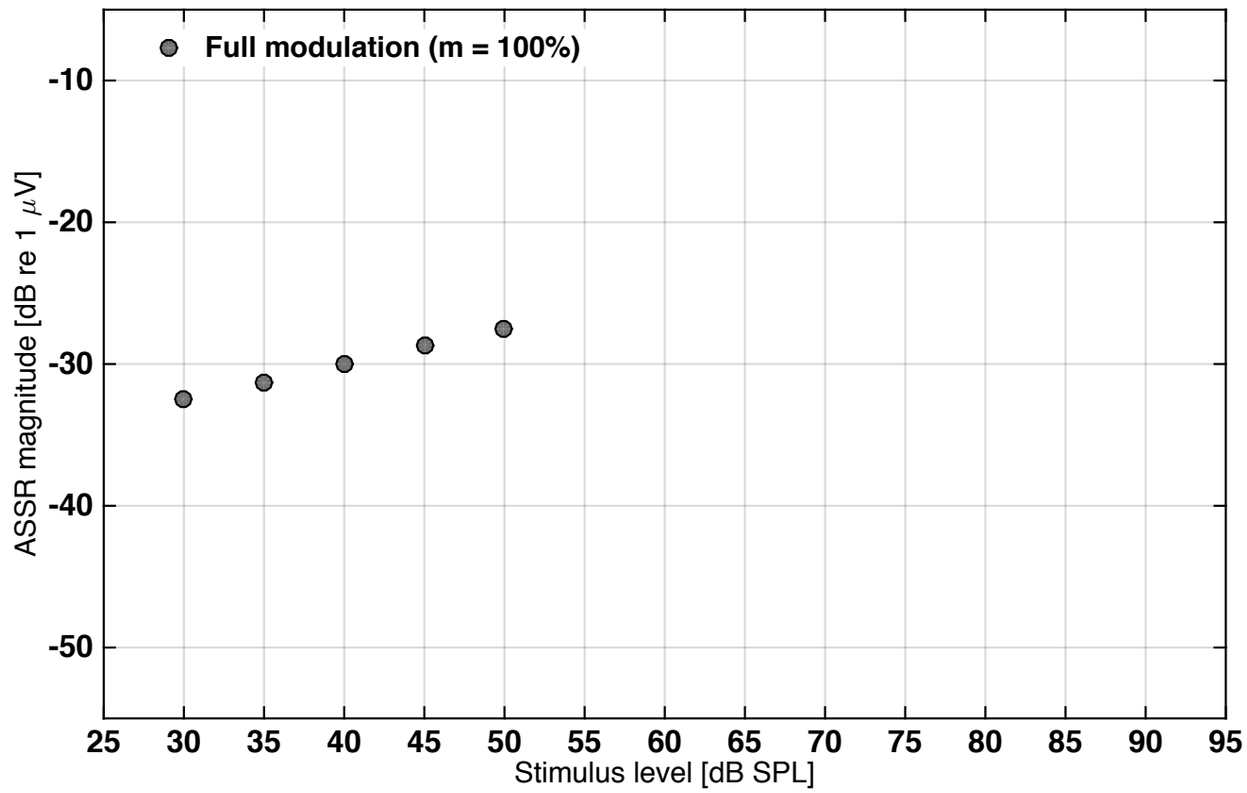
Potential explanation

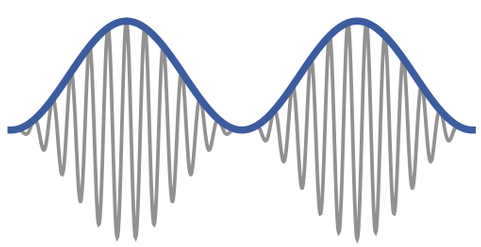




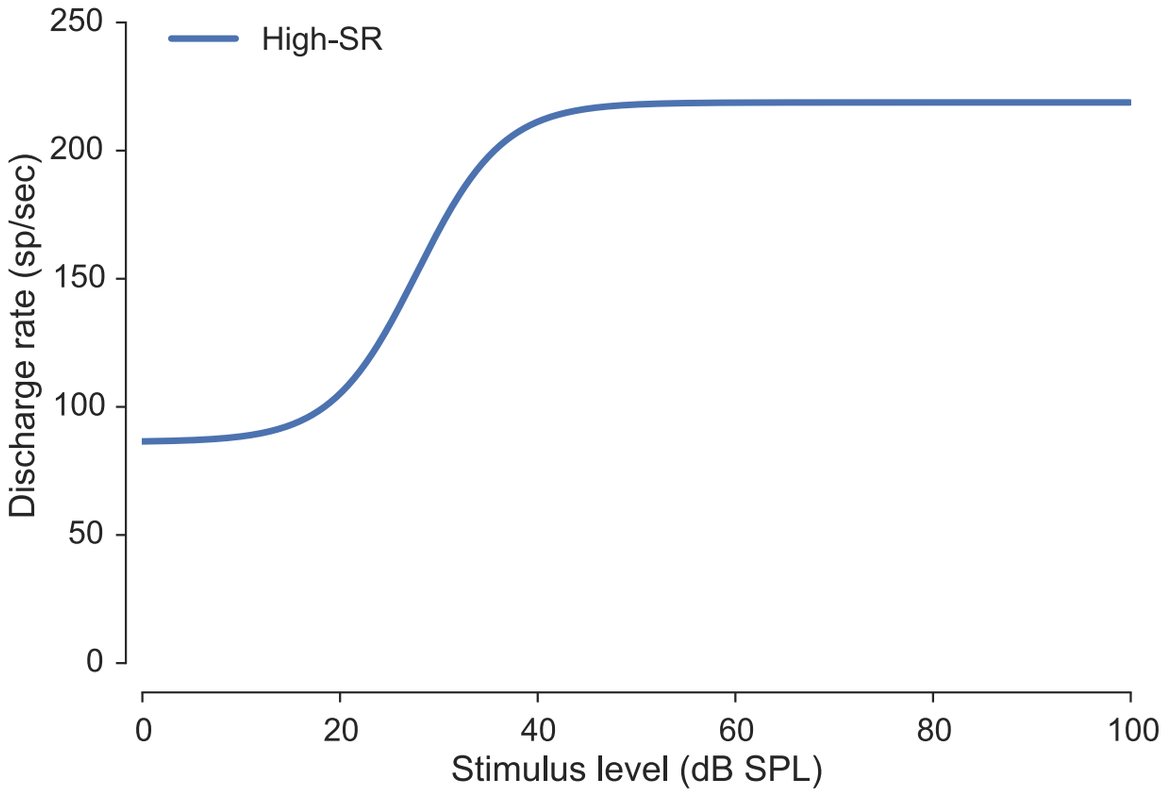
Potential explanation

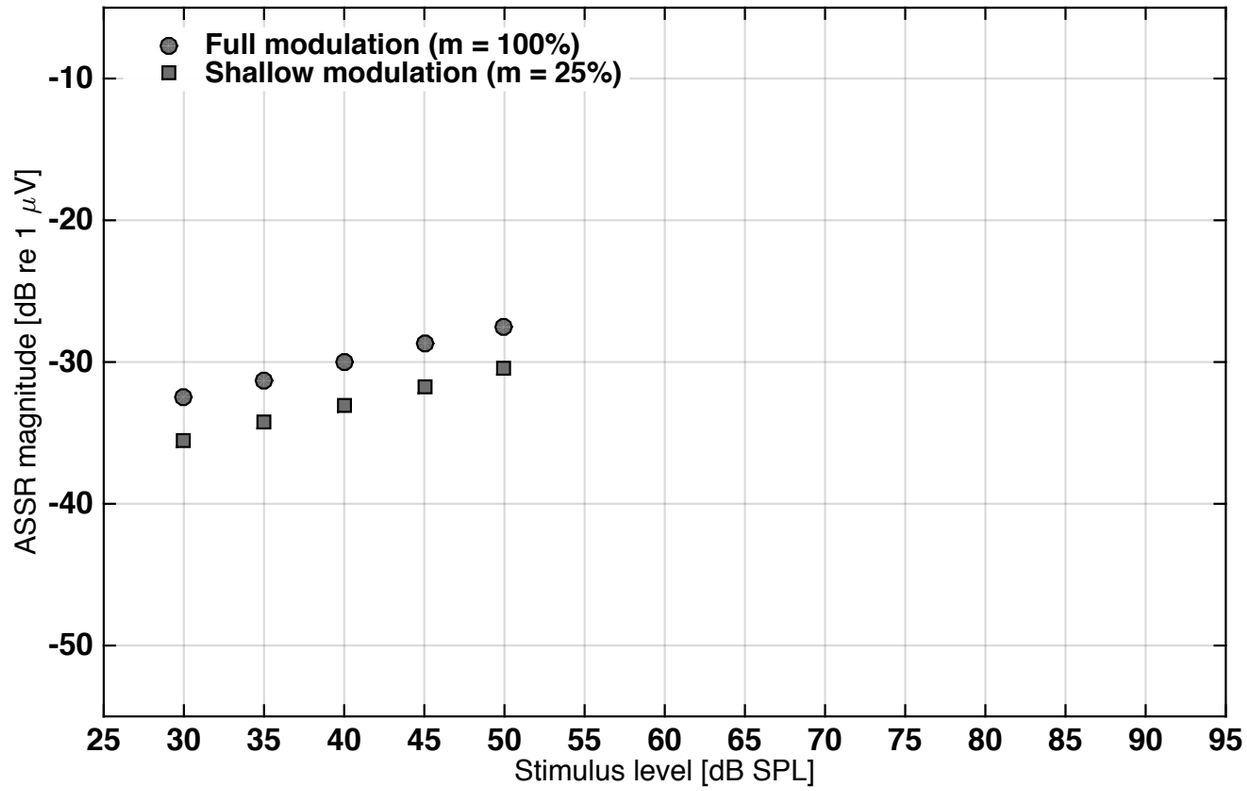


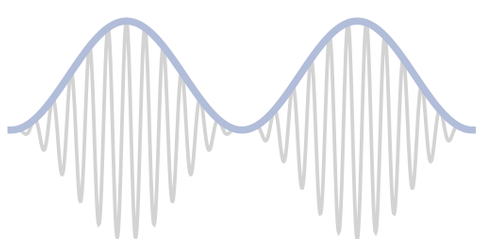


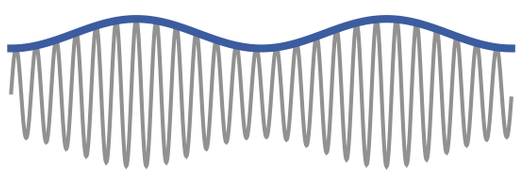


Potential explanation









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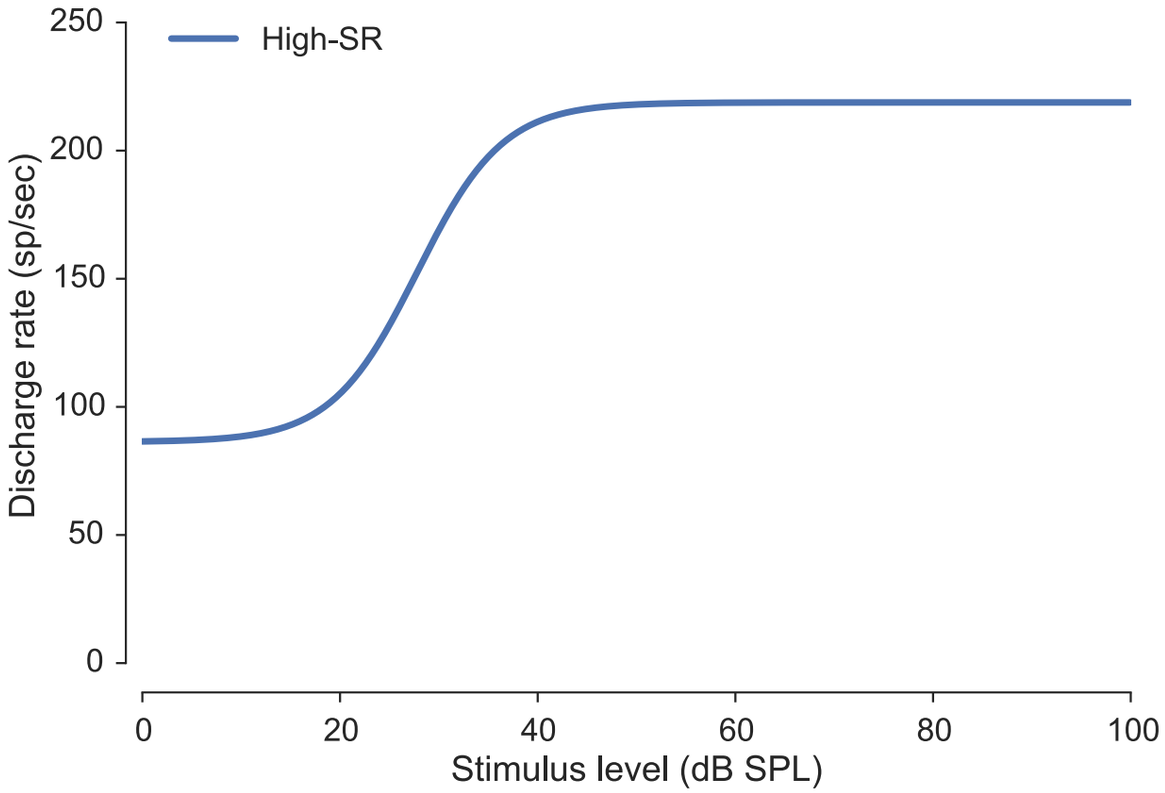

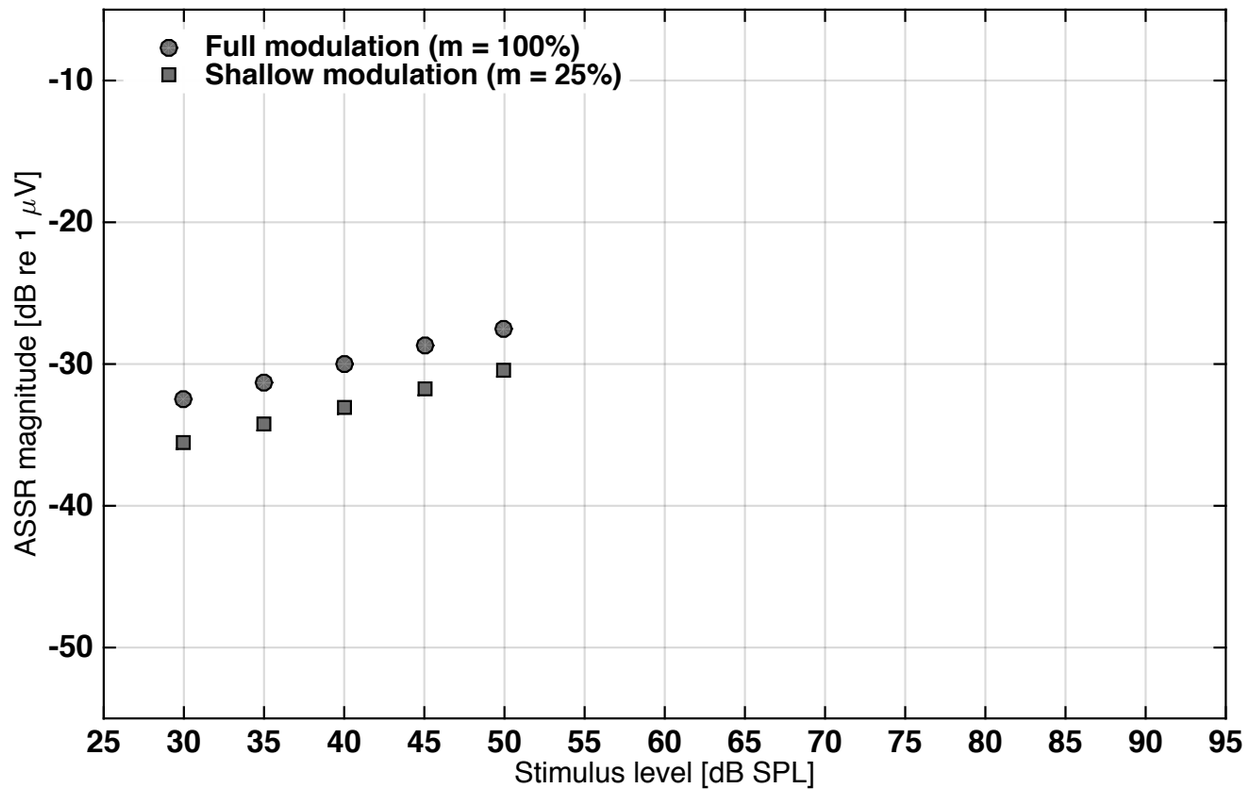

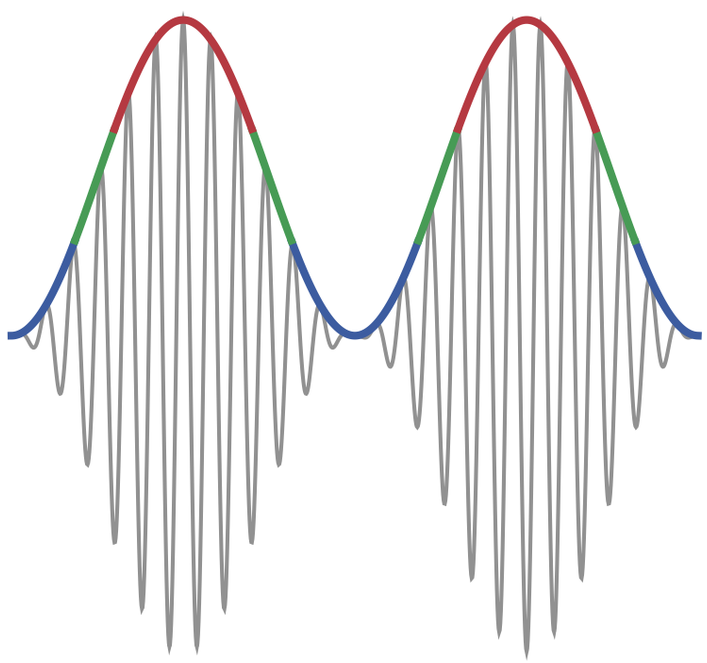

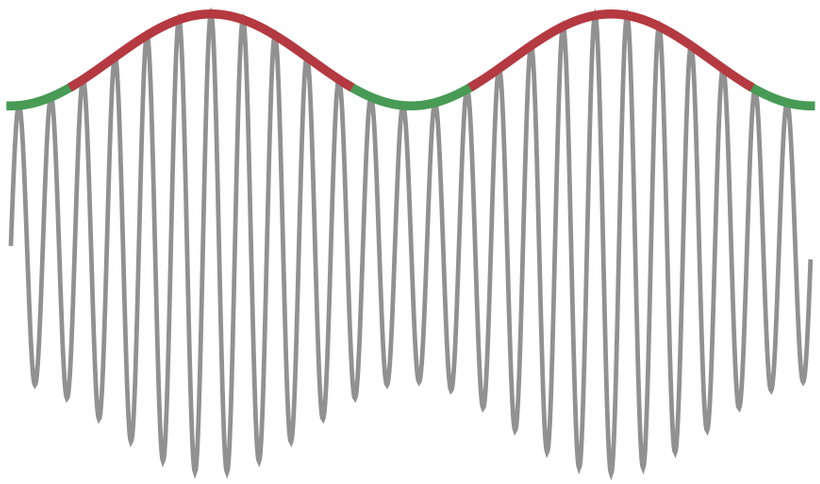

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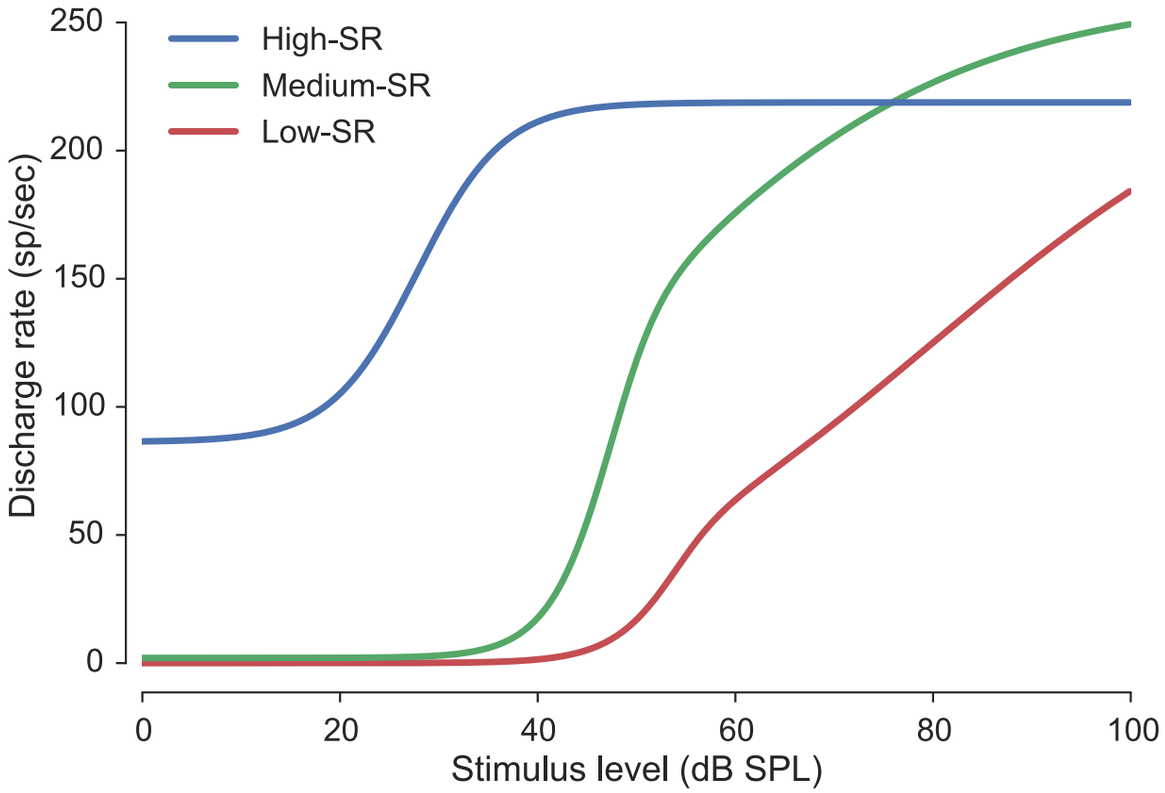

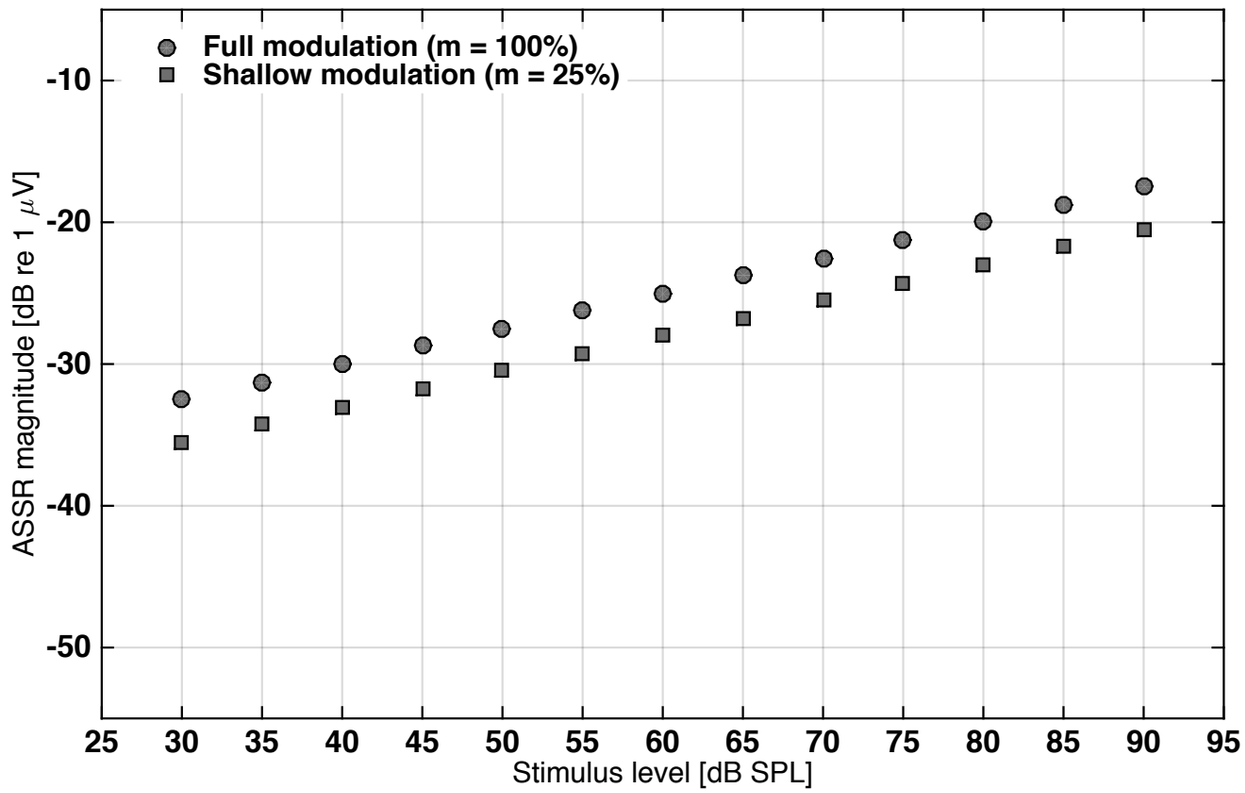

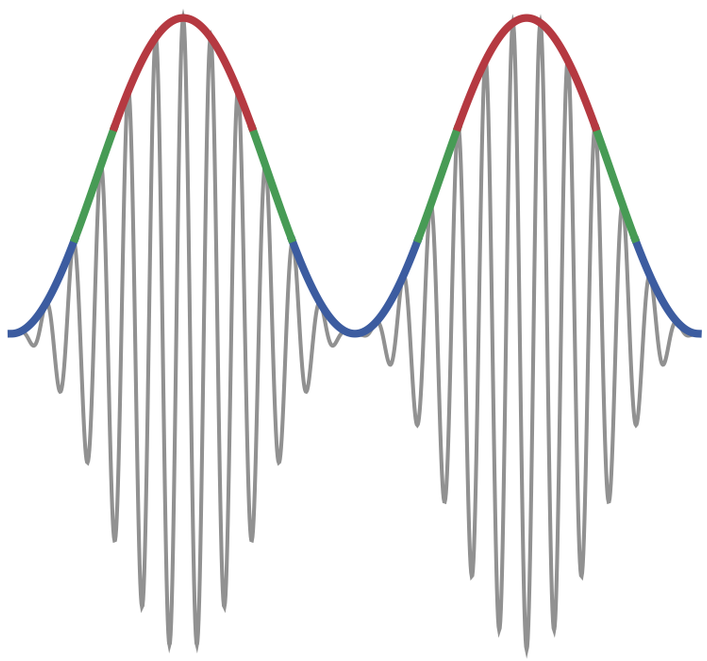

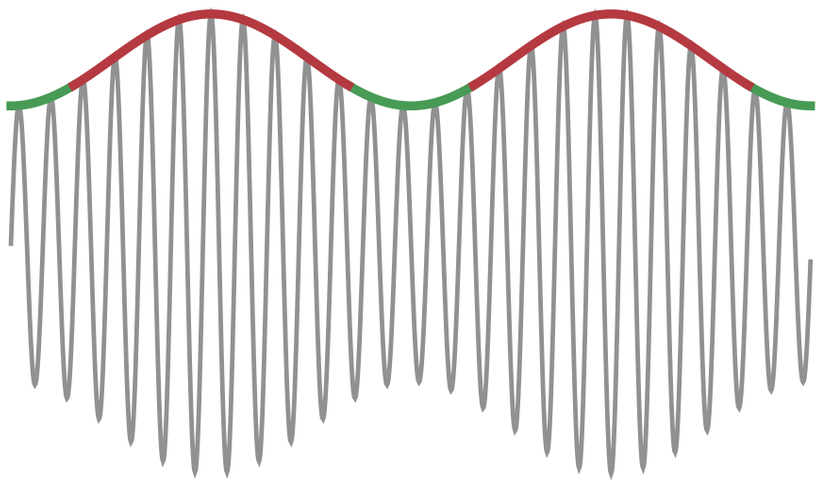

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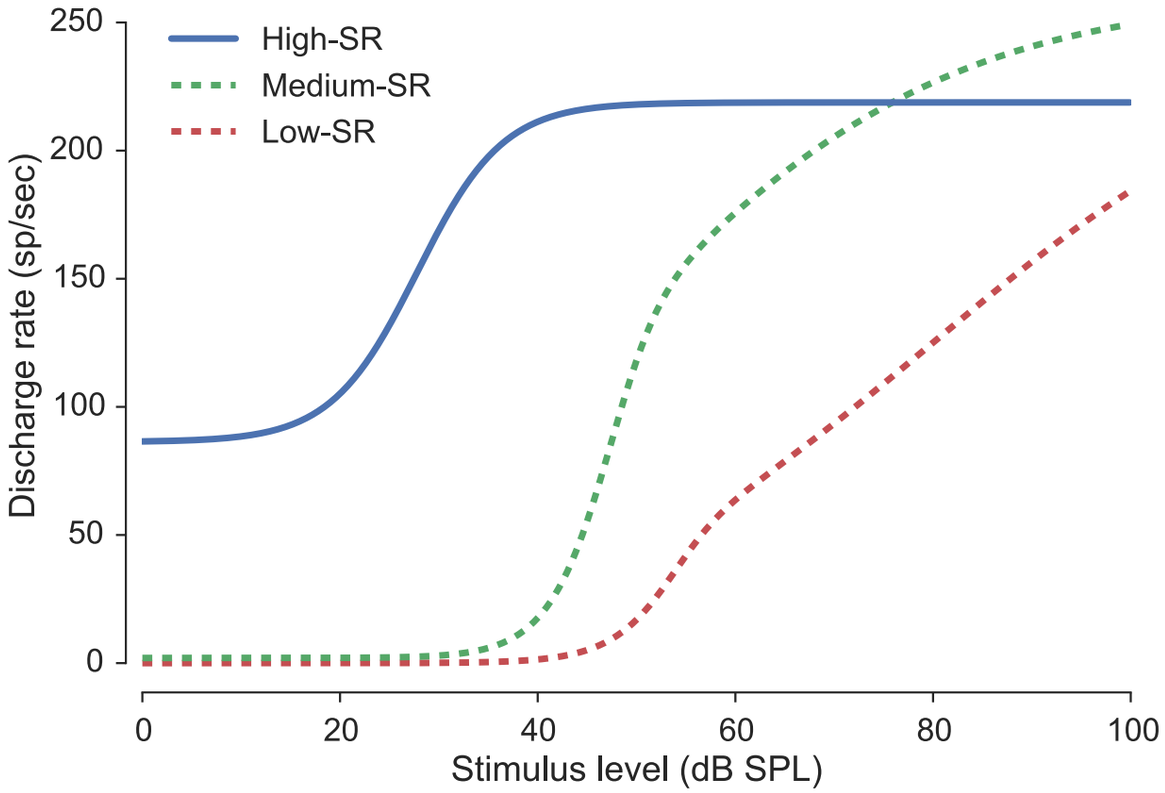

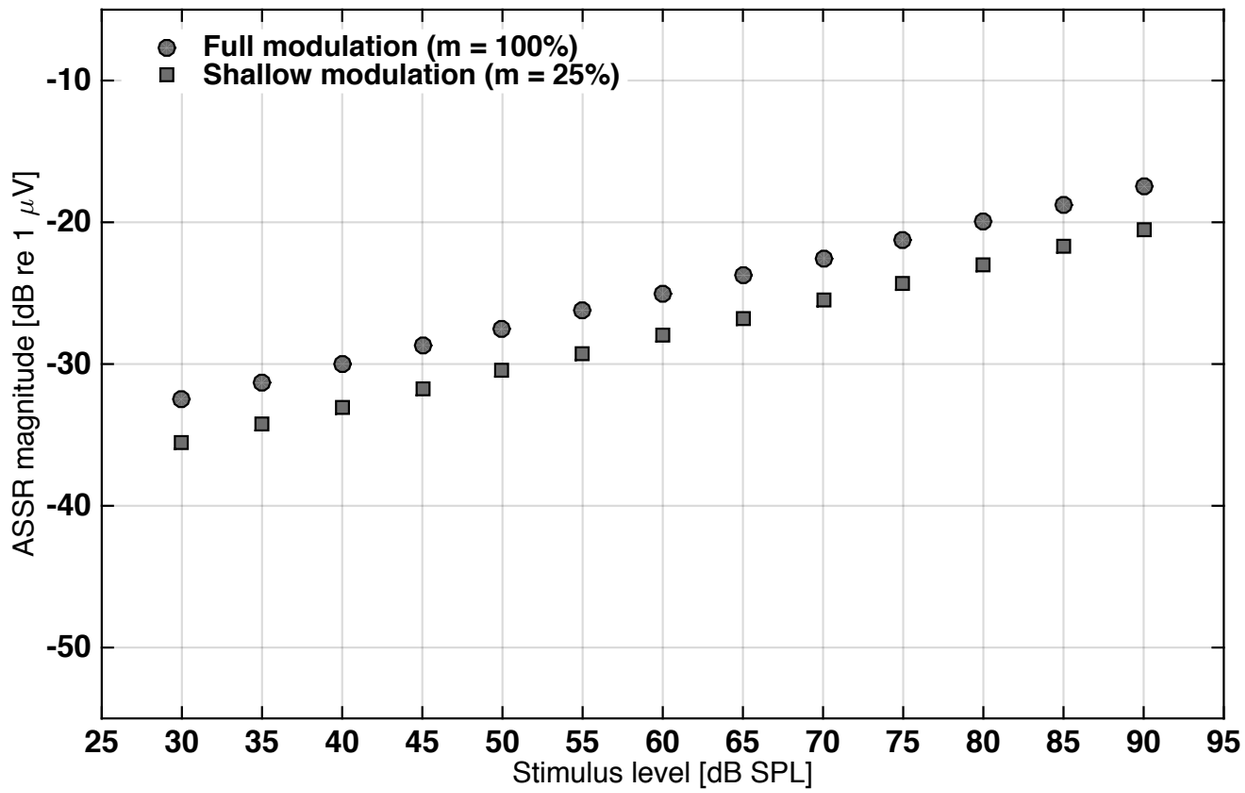

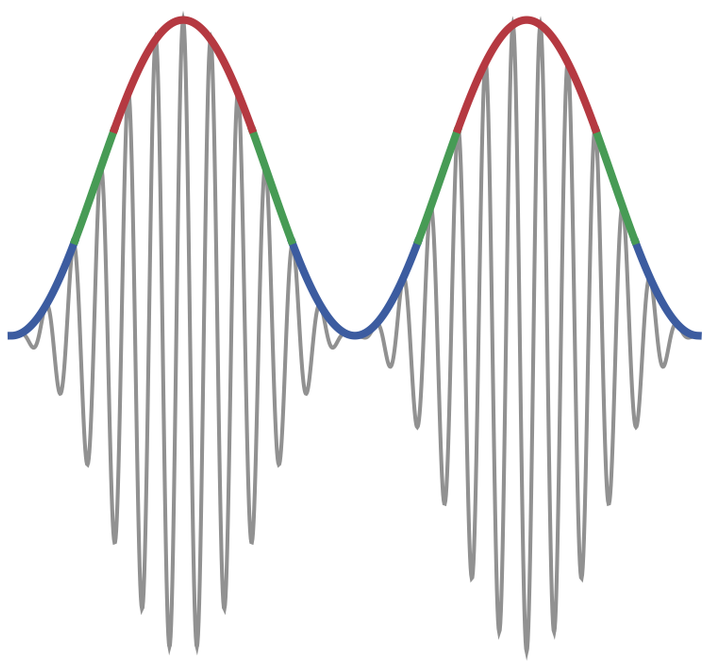

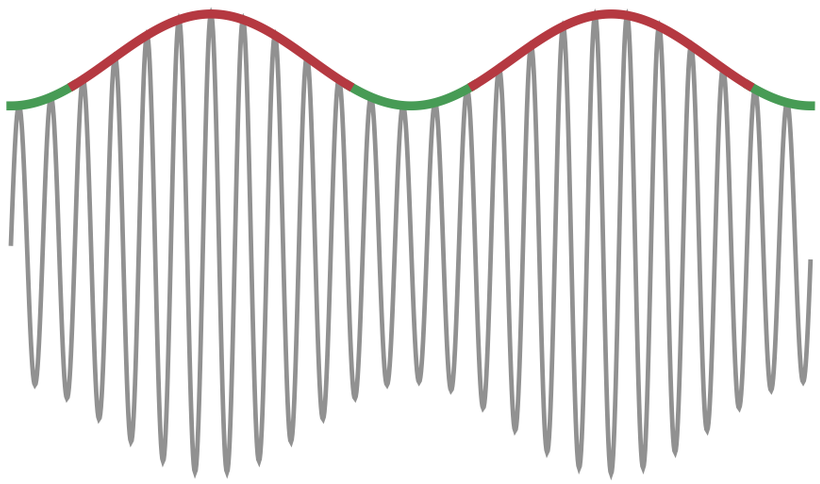

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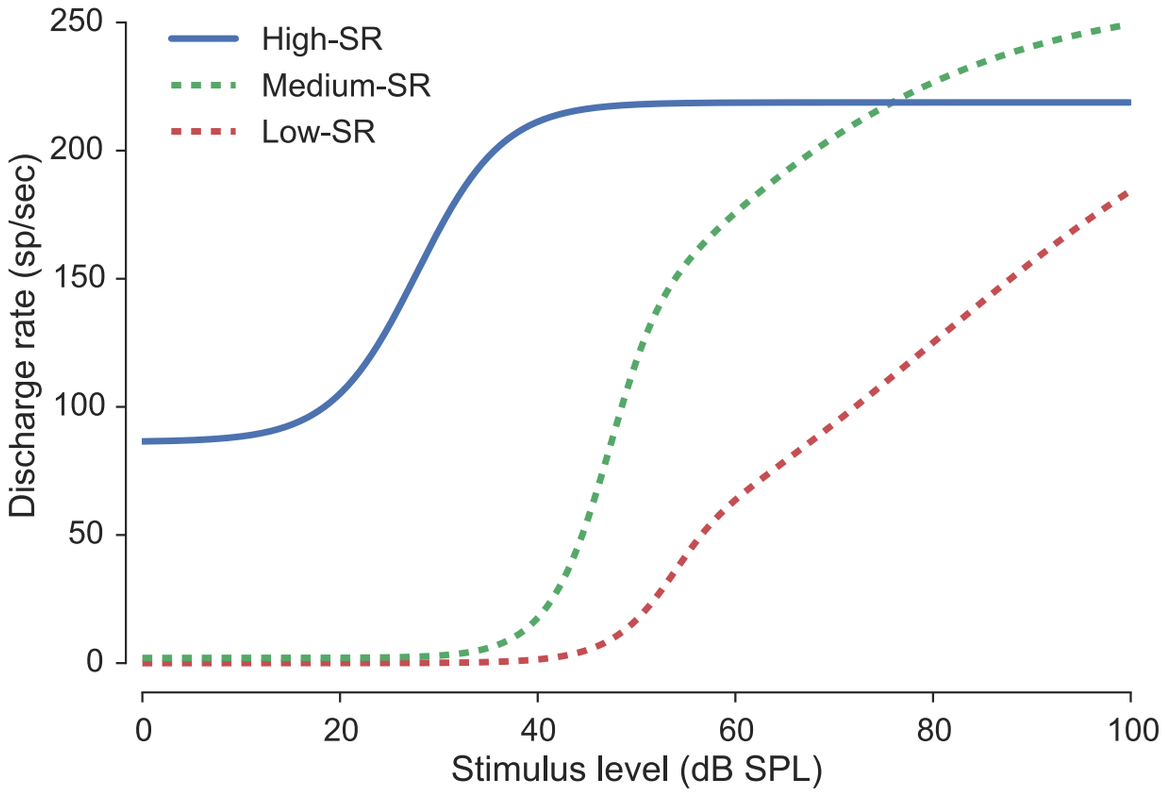

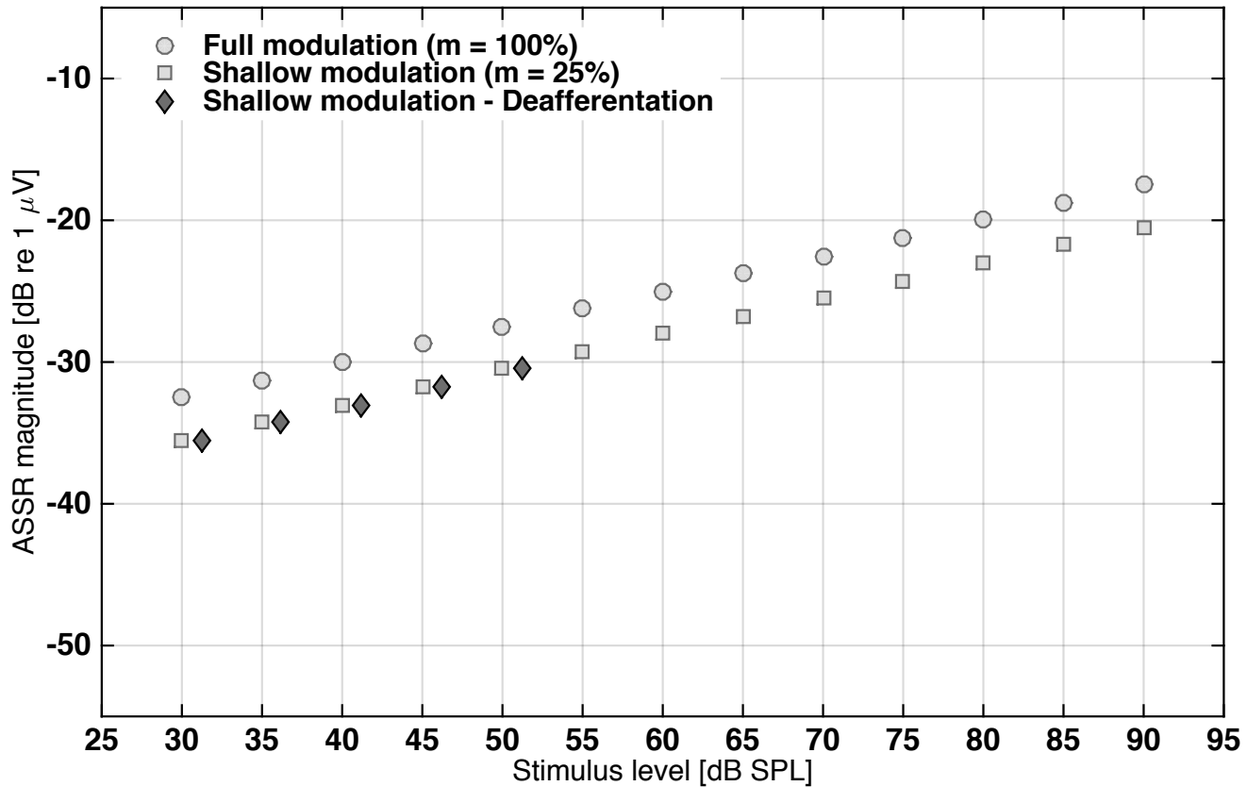

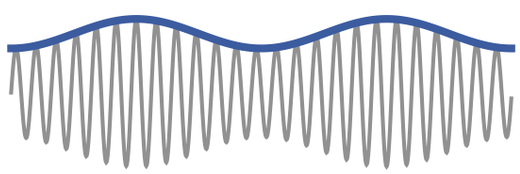

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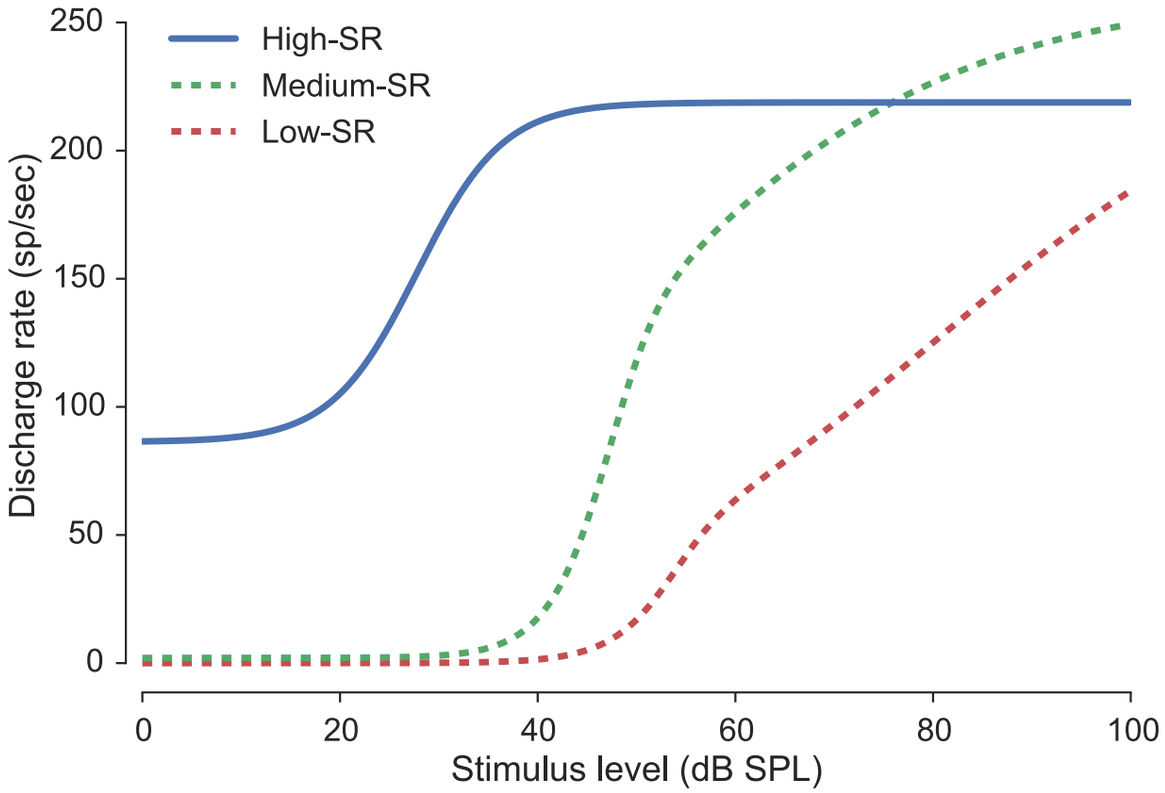

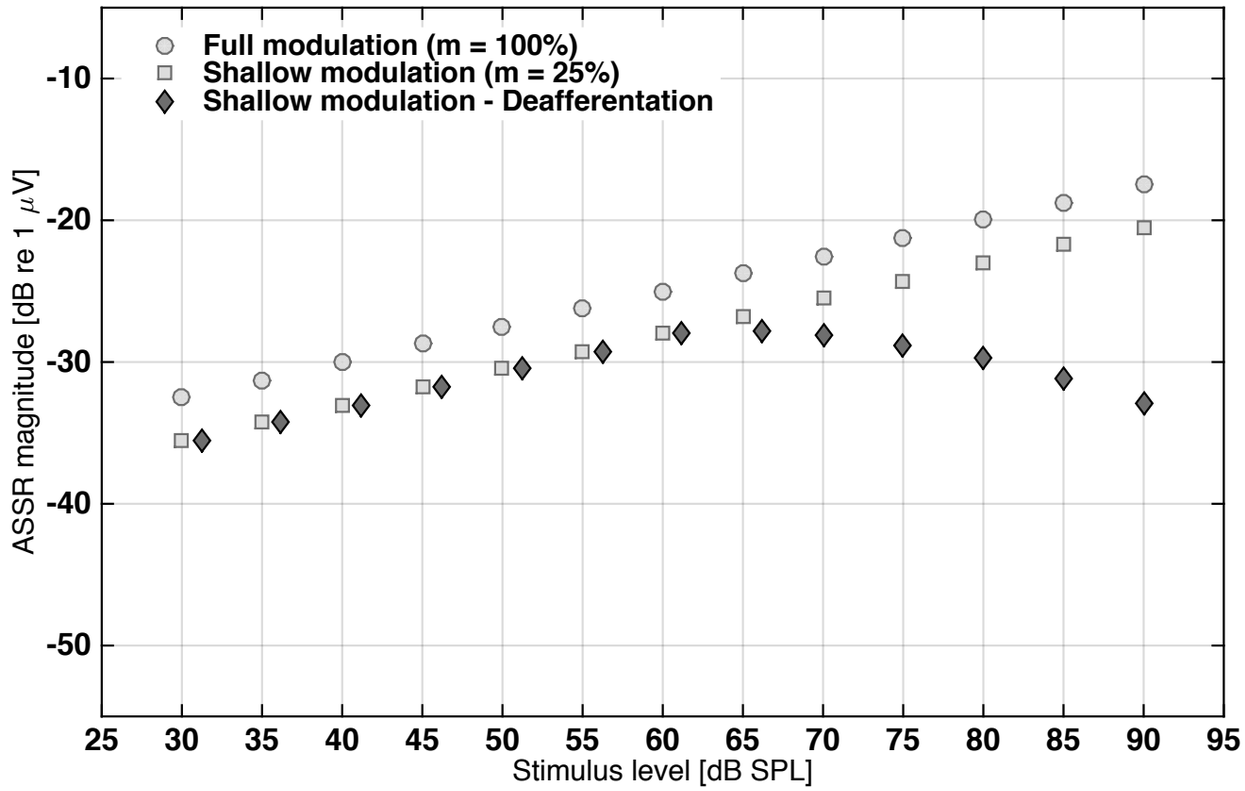

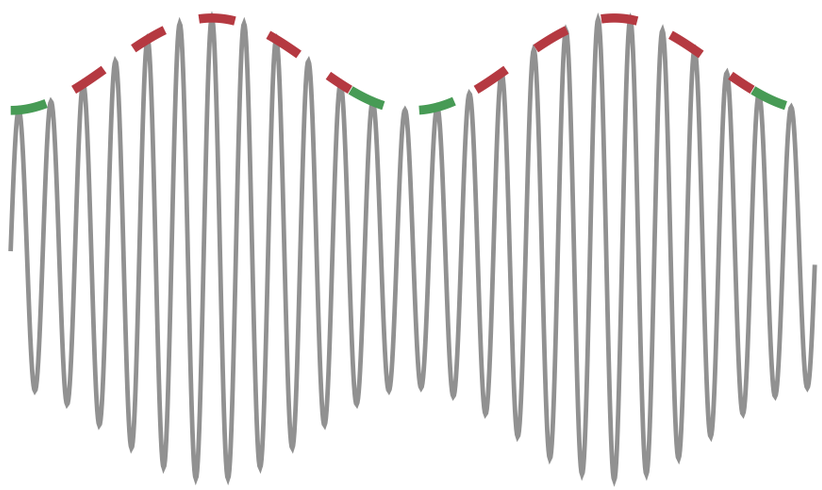

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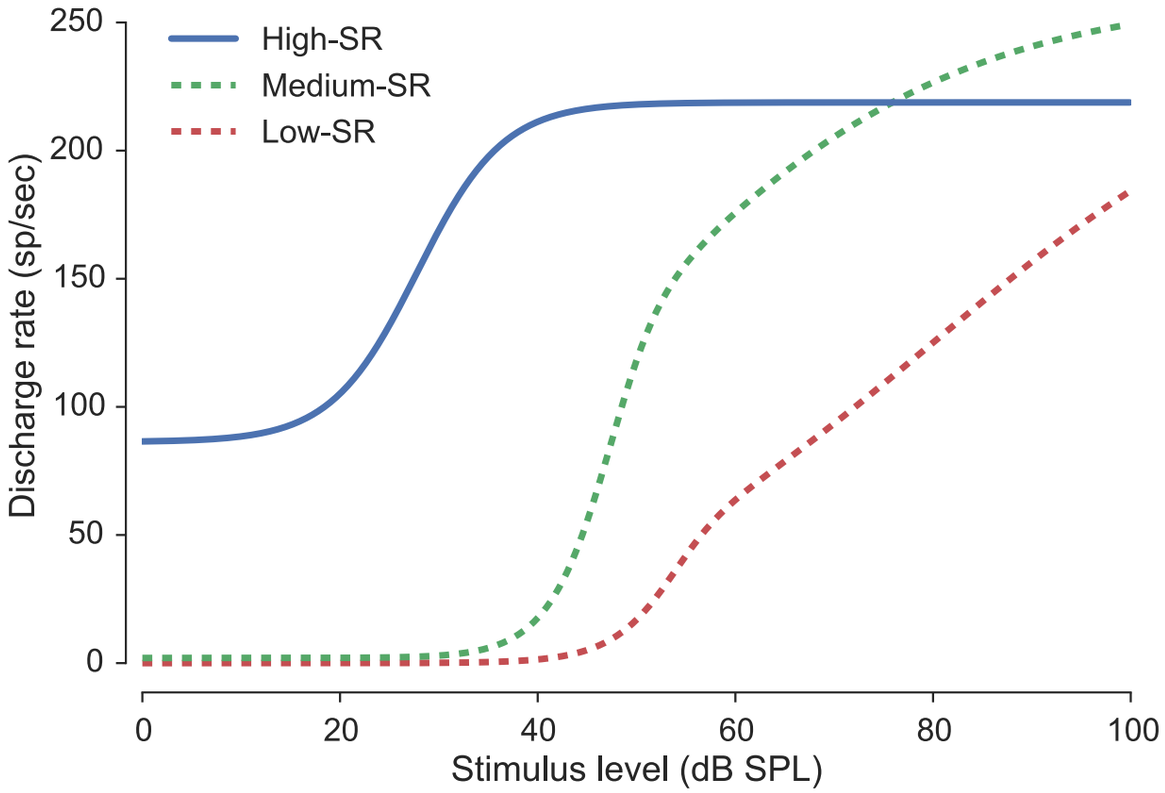

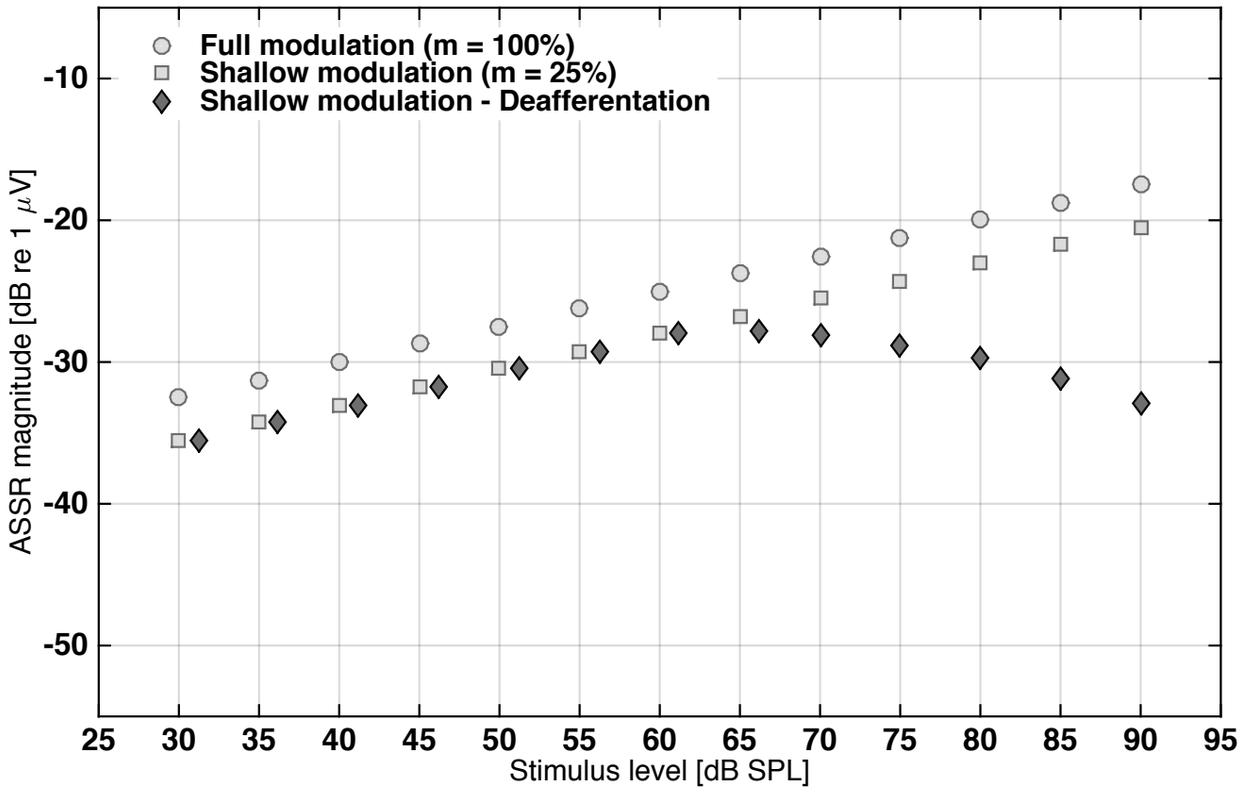

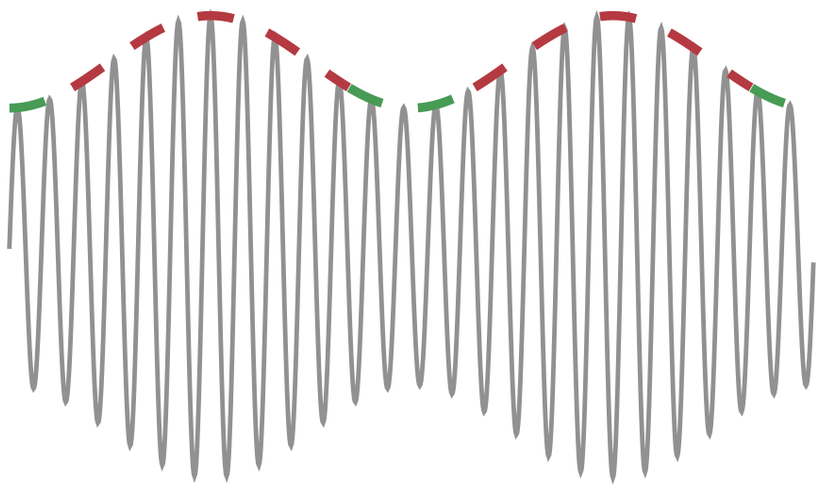

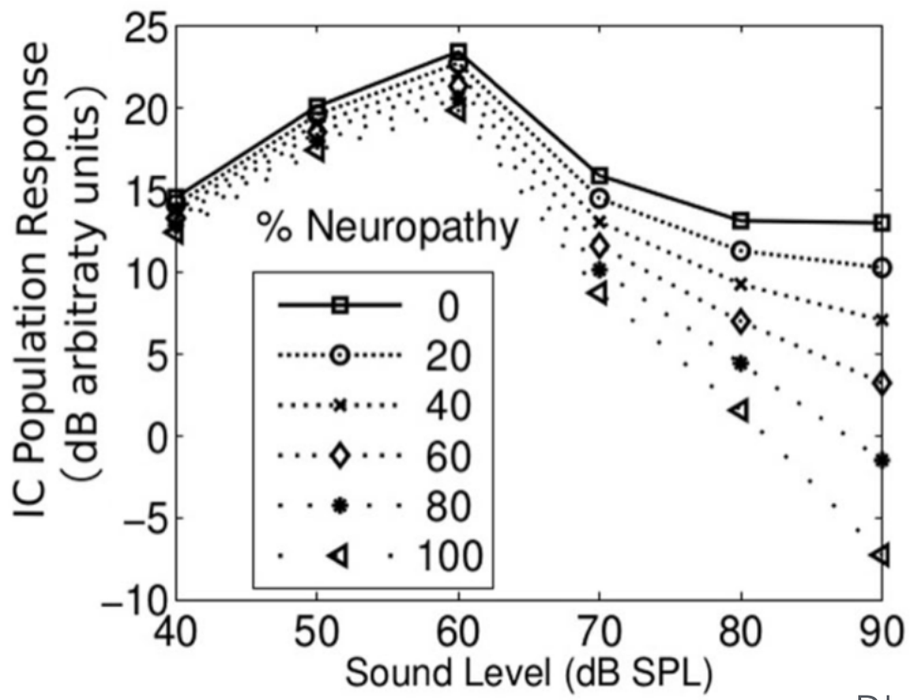

Bharadwaj *et al.* (2014)

Pilot results: Individual NH subjects

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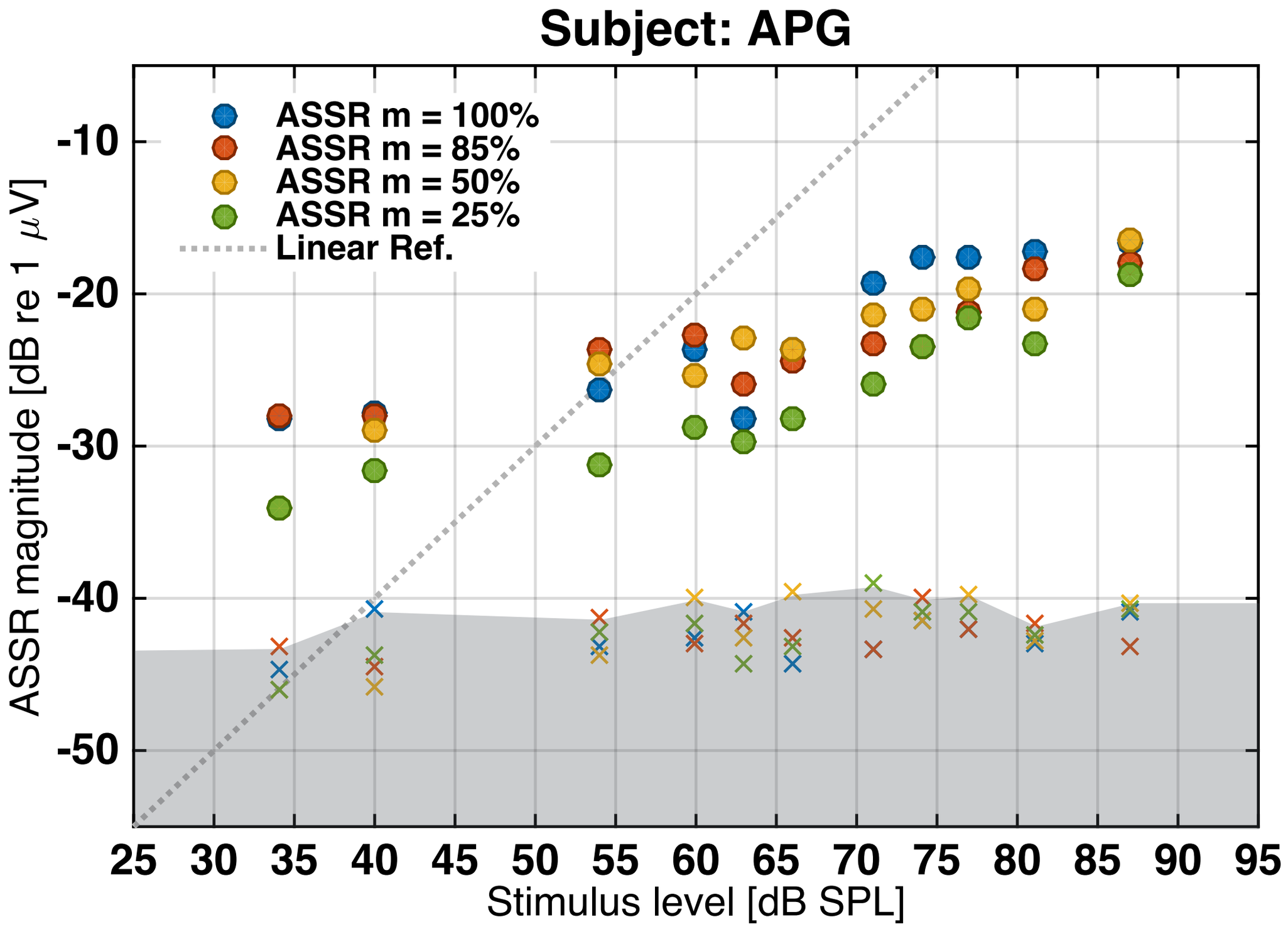
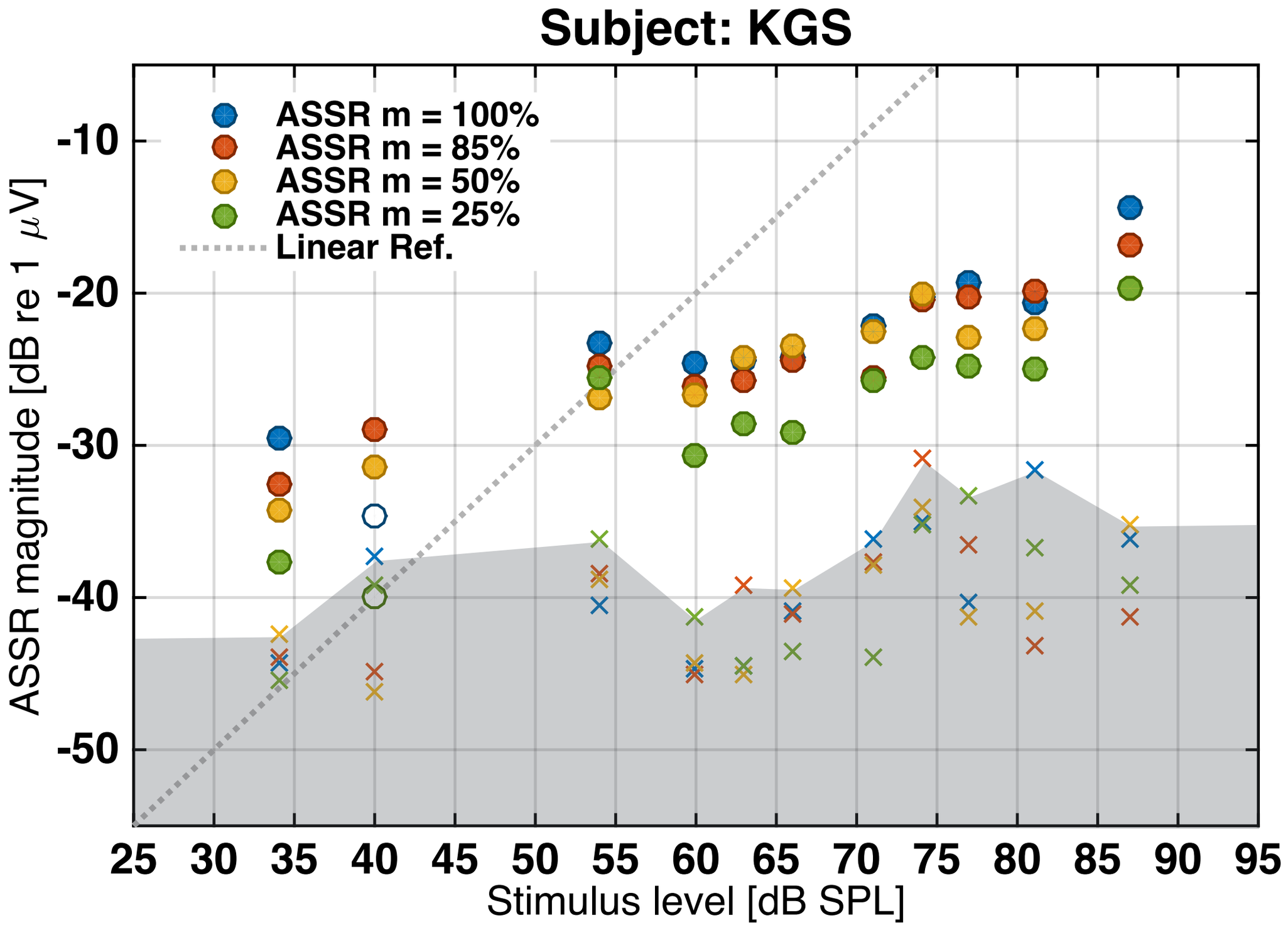
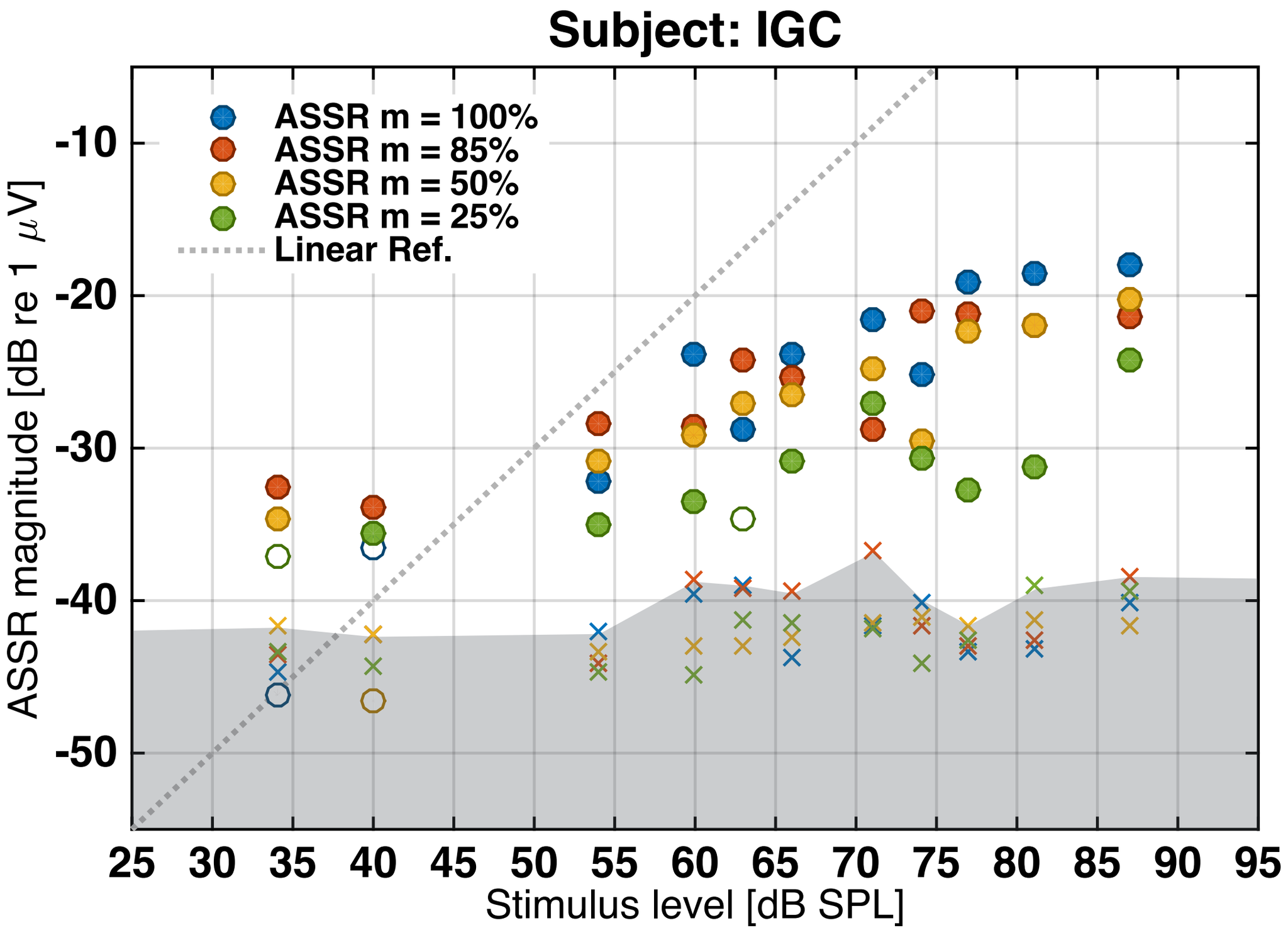


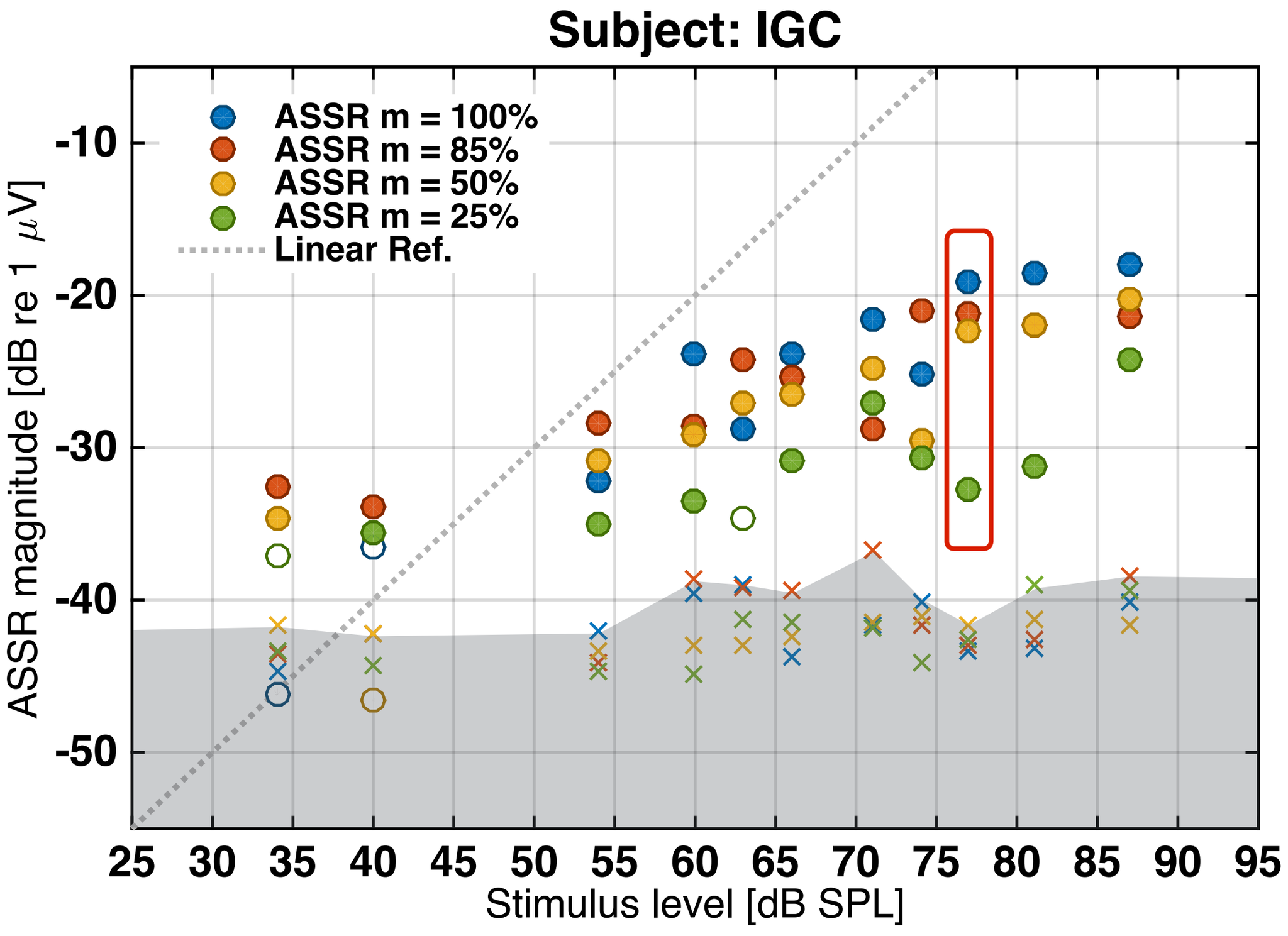
Pilot results: Individual NH subjects



Pilot results: Individual NH subjects



Pilot results: Individual NH subjects



Bharadwaj *et al.* (2015)

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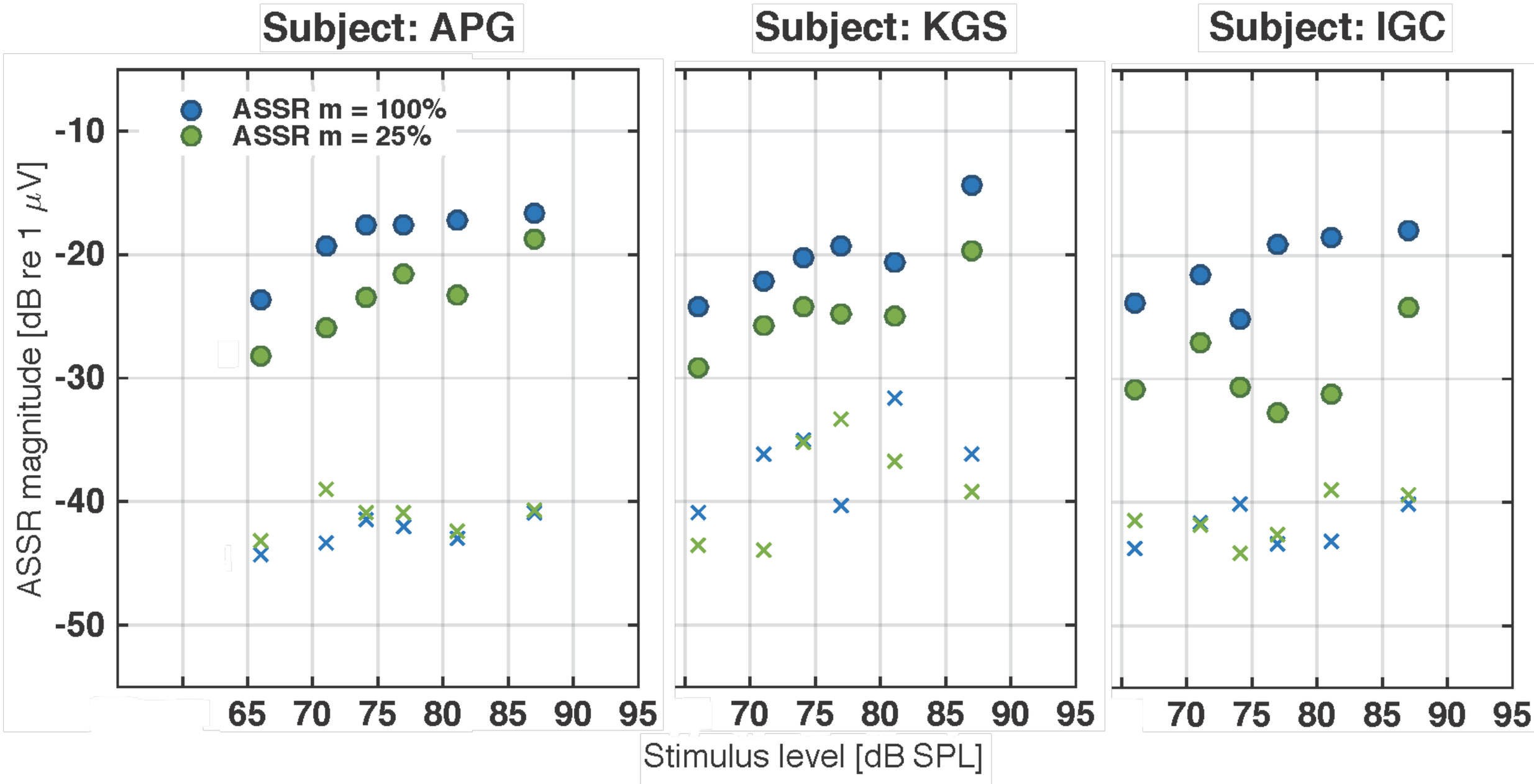


Next steps

Next steps

Next steps

Low exposure NH

Next steps

Low exposure NH

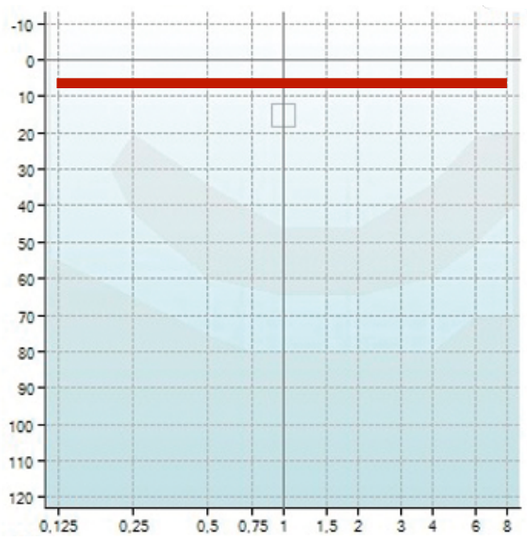
High exposure NH

High exposure mild HI

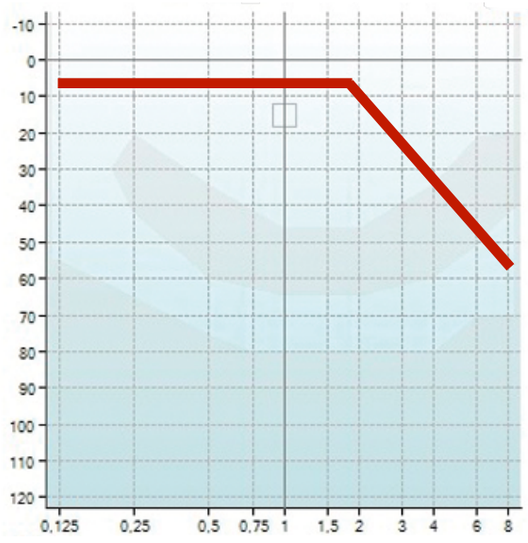
Next steps

Low exposure NH

High exposure NH



High exposure mild HI



Conclusions

- ASSR are already used in the clinics to **estimate thresholds** objectively

- **ASSR growth functions** are suggested to be used as a tool to **assess compression** (and loss of compression) at different frequencies simultaneously

- We hypothesize that ASSR growth functions at higher stimulation levels using shallow modulations **reflect the integrity of ANFs**

Thank you!

Mange tak!

Moltes gràcies!